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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 273
The Microscopic Inspection of Steel (illustrated).. 274
Power Distribution and Multiphase Current Transmission for Street Railways 275
An American Locomotive for South Africa (illustrated) 277
Bacterial Test of Mechanical Filters at Lorain, O.. 278
Rules for the Use of Private Fire Supplies, Providence Water-Works 279
Details of Gates for the Cascades Canal Lock (with full-page plate and other illustrations)..... 283
Rain Gushes in Thunderstorms 283
Machines for Inserting Valves and Branches in Water Mains Under Pressure (illustrated)..... 284
Bids for Three 35,000,000-Gallon Pumping Engines for the Metropolitan Water Board, Boston 285
Sewage Disposal on Land at Litchfield, Conn..... 285
Progress of Track Elevation by the Chicago & Northwestern Ry. in Chicago (illustrated)..... 286
The New York Central & Hudson River R. R. Wreck near Garrisons, N. Y. 286
The 16th Annual Convention of the American Street Railway Association 287
EDITORIAL NOTES 280
The Accident on the New York Central & Hudson River R. R. near Garrisons—A New Method of Measuring Stress in Beams and Girders.
EDITORIAL:
The Bacterial Test of Mechanical Filters at Lorain, O., and Resulting Suggestions 281
LETTERS TO THE EDITOR 282
The Railway Bridge over the St. Lawrence at Quebec—A Good Day's Journey by a Steam Motor Carriage—Credit for the Design of the Harlem Ship Canal Bridge.

A TRANSCONTINENTAL RAILWAY across Honduras, from Puerto Cortez on the Atlantic Coast to the Bay of Fonseca on the Pacific Coast, is proposed in a concession recently granted by the Honduras Government to a syndicate of American capitalists, among whom are Chauncey M. Depew, W. Seward Webb, John Jacob Astor, Chas. McVeigh and other well-known men. According to the report of the U. S. Consul at Tequcigalpa, Honduras, the government grants the syndicate the railway with all its appurtenances, now being operated from Puerto Cortez to La Pimienta, a distance of about 30 miles; a subsidy of 100 ft. of land on each side of the entire line; exclusive right of transit over land and water throughout the route; 5 sq. miles of land for every mile of railway; the free use of all construction material which can be obtained from government land; exclusive mining rights on all land granted to the railway, and various privileges in financing the scheme. The railway is to be completed within six years, under the following conditions:

The width of the line is not to be less than 3 ft. 6 ins. Five miles shall be constructed within the first year. At the end of the second year, 25 miles are to be finished; at the end of the third year, 50 miles; at the end of the fourth, the road must have arrived at Comayagua; at the end of the sixth year, the line is to be completed and opened to the public. If the company fails to comply with these conditions, it shall pay to the government 15% of the gross receipts of the line until the conditions are fulfilled, an extension of time having been granted. At the expiration of this extension of time, if the said number of miles has not been completed, the road will pass into the hands of a trustee. The government mail is to be carried free, and officials (not traveling in a private capacity) are to be subjected to no charge. The transportation tariff shall not exceed that on the portion of the line now in operation (except in the case of interoceanic traffic). The cost of transportation of products of Central America is to be made as low as possible. Passengers and freight engaged in interoceanic travel or transportation are not to be subjected to customs duties. All materials for the railway are to be admitted into the country free. Foreign colonists and workmen can be introduced (with the exception of negroes and Chinese), and the same will be exempt from personal taxes for ten years. The syndicate can issue bonds (not to exceed $20,000 in gold for each mile of road) and can transfer rights in the property to any one, except to foreign governments. After 75 years, the government will have the right to purchase the road; the same option will be given at the end of each five years following; and at the end of 99 years, the road and all its appurtenances will become the property of the state.

The syndicate also undertakes to liquidate the public debt of Honduras and is granted very extensive banking and customs powers by the government for this purpose. This is by far the most comprehensive foreign government concession which has been granted to Americans for some time. The U. S. Consul states that by it the syndicate secures practical control of the entire trade of the country.

THE UNION ELEVATED RAILWAY LOOP at Chicago is now in full operation, and the three elevated railways are running their trains around it. Eventually it will be used by four lines, but the fourth (the Northwestern Elevated Ry.) is not completed. The loop is operated by an independent company, and it is equipped for electric traction on the third-rail system, but the South Side Elevated Railway runs its trains by steam locomotives, the change from steam to electric traction not being yet completed. The Metropolitan West Side Elevated Ry. and the Lake St. Elevated Ry. are operated entirely by electricity. The loop has two tracks, and the trains of the West Side and South Side lines pass round in one direction on the inner track, while the trains of the Lake St. line pass round in the opposite direction on the outer track. The time occupied in passing round the loop (which has several stations) is now from 16 to 18 minutes, but it is expected to reduce this to 15 minutes when the trainmen have got used to the line. To prevent passengers from one line changing to trains of another line at stations used by both lines, the trains will stop at opposite ends of the platform, and a fence across the middle of the platform will compel passengers from one line to pass through the Union company's ticket office in order to reach the other line. The opening of the loop has already resulted in a marked increase in the traffic and earnings of the elevated railways, none of which have hitherto had access to the business center of the city.

FILLING TRESTLES BY HYDRAULIC POWER has been carried on for a year or two on the Cascade division of the Northern Pacific Ry. The annual report of the company, just issued, states that about 320,000 cu. yds. of earth have been thus deposited in embankments, at an average cost of 4.7 cts. per cu. yd. At one trestle it was necessary to pump the water, and the cost of moving earth at this place was 13.5 cts. per cu. yd.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the New York Central & Hudson River R. R., near Garrisons, N. Y., about 50 miles north of New York city, in the early morning of Oct. 24, and resulted in the death of 20 and the injury of 14 persons. A full account of the accident is given in another column.

THE FAILURE OF AN IRON BRIDGE is reported from Sonoma, Cal., on Oct. 16. The bridge was in course of construction over Sonoma Creek, about six miles from the town of that name, when without warning the bridge crashed to the ground, carrying with it the scaffolding and several men, one of whom may die from injuries received.

THE LONG ISLAND R. R. TUNNEL under the East River, in support of which the special rapid transit commission appointed by the Mayor of Brooklyn, N. Y., presented a lengthy report last January (Eng. News, Jan. 14, 1897), is now before the Board of Aldermen of New York for consideration. This tunnel is proposed to run from the terminus of the Long Island R. R., in Brooklyn, underneath the streets of that city and under the East River and Cortlandt St., in New York. The company organized to build the tunnel is the Brooklyn, New York & Jersey City Terminal Ry. Co., and this company has recently petitioned the Board of Aldermen of New York for permission to construct the tunnel under certain streets in that city. The President of the Brooklyn transit commission, Mr. Eugene G. Blackford, has recently made the statement that he expected to see the work of construction begun before the end of this year.

A TANK LOCOMOTIVE WEIGHING 92 TONS (gross), which is one of the heaviest engines in the world, has been built for the Indian State Railways (5 ft. 6 ins. gage) by Neilson & Co., of Glasgow, Scotland. Its total weight is 206,276 lbs., while the Johnstone duplex engines on the Mexican Central Ry. weigh 230,000 lbs. The tank engines of the St. Clair tunnel weigh 195,000 lbs., and the decapod pusher engines of the Erie R. R. weigh 192,000 lbs. The Indian engine has eight coupled driving wheels, with single leading and trailing axles, these latter being carried in radial axle boxes. The engine has outside cylinders, an extension smokebox, and an enclosed cab between the firebox and the rear coal bunker, the tanks being on each side of the boiler. The two middle pair of driving wheels have blind tires. The leading dimensions are as follows:

Driving wheels	4 ft. 3 ins.
Leading and trailing wheels	3 " 7 "
Wheelbase, driving	16 " 0 "
" total	31 " 3 "
Weight on driving wheels	155,932 lbs.
" on leading "	19,376 "
" on trailing "	30,968 "
" total	206,276 "
Cylinders	20 × 26 ins.
Connecting rod, length c. to c.	9 ft. 9 "
Boiler, diameter	5 " 4¼ "
" height from rail to center line	8 " 0 "
" pressure	180 lbs.
Firebox (inside)	7 ft. 1¼ ins. × 4 ft. 1¼ ins.
Smokestack, diameter	1 " 3½ "
" height from rail to top	13 " 6 "

FOUR-CYLINDER LOCOMOTIVES are now being tried on at least two railways in England. In our issue of Sept. 30 we described some four-cylinder simple and compound engines of the London & Northwestern Ry., and now we learn that the Glasgow & Southwestern Ry. has built an eight-wheel engine having four high pressure cylinders. The two inside cylinders, 14½ × 26 ins., are placed under the smokebox, with the valves between them. The outside cylinders are 12½ × 24 ins., with the valves on top of the cylinders and worked by a rocker shaft from the link motion. The driving wheels of this engine are 6 ft. 9½ ins. diameter. The four-cylinder simple engine of the London & Northwestern Ry. has all its cylinders 15 ins. diameter, while the compound has two of 15 ins. and two of 19½ ins. diameter.

THE YERKES OBSERVATORY, at Williams Bay, Wis., was formally dedicated and turned over to the University of Chicago on Oct. 21. The buildings were donated by Mr. Chas. T. Yerkes, the well-known street railway owner, of Chicago, Ill., who also presented to the University the large 40-in. refracting telescope which is mounted in the main dome. This is considered to be the most complete astrophysical observatory in the world, and we shall describe some of its principal features in a future issue.

AN AMERICAN MANUFACTURER OF CAST-IRON pipe, according to the London "Contract Journal," has offered to furnish the gas department of the city of Glasgow with 900 tons of large sizes of pipe at about $5 per ton cheaper than the home bidders. The standing of the American bidder was to be investigated before awarding the contract. The same paper states that the Maryland Steel Co. has received a contract for 8,000 tons of steel rails, to be delivered in Calcutta for the East Indian State Ry., at about $5 per ton less than the lowest British tender.

AN ELECTRIC MOTOR DRIVING A CABLE railway is in operation in Kansas City, Mo., where during the past summer the Walker Co., Cleveland, O., installed a 1,500 K-W. generator for the Metropolitan Street Ry. Co. This machine now furnishes current to propel both electric and cable cars. To operate the cable machinery an old 30 K-W. General Electric generator was converted into a motor and belted to the driving machinery. In this way they were able to dispense with a 250-HP. engine formerly used to drive the 26,000 ft. of cable. The experiment has proved so successful that other motors will be installed and eventually the whole system will be transformed into an electric road. The first month after the change described above was made the operating expenses of this particular station were reduced 50%, from $1,200 per month to about $600.

A LARGE LAKE STEAMER and two barges which it will tow are now being built by F. W. Wheeler & Co., of Cleveland, O., for the Bessemer Steamship Co. for carrying iron ore on the great lakes, and the steamer will be the largest vessel on the lakes. It will be 475 ft. long over all, 455 ft. on the keel, 50 ft. beam and 29 ft. 6 ins. deep, with a hold capacity of 6,500 tons of ore on a draft of 17 ft. The engine will be of the quadruple-expansion marine type, with cylinders 28, 40, 59 and 85 ins. diameter and 42 ins. stroke. The barges will be 450 ft. long, 50 ft. beam and 28 ft. 6 ins. deep, each with a capacity of 7,000 tons on a draft of 17 ft. It will be seen that the three vessels will transport, on a draft of only 17 ft. of water, the enormous quantity of 20,500 tons of ore at a trip.

WATER PIPE AND PIPE INSPECTION CONTRACTS covering 35,000 tons of 6-in. to 48-in. cast-iron pipe, have been awarded by the city of Chicago. The inspection contract has been awarded to the Pittsburg Testing Laboratory. The terms for the inspection being based upon a tonnage rate which is highest for the 6-in. pipe and gradually decreases for the larger sizes. The order for the pipe was divided as follows, and it will be seen that a large proportion will be 36-in. pipe:

Addyston Pipe & Steel Co., 32,500 tons:

117	pieces of	48-in.	pipe, weighing	9,350	lbs. each.
8,360	"	36-in.	" "	5,400	" "
1,540	"	30-in.	" "	4,230	" "
2,402	"	24-in.	" "	3,000	" "
3,354	"	16-in.	" "	1,500	" "

South Pittsburg Pipe Works, 2,300 tons:

428	pieces of	12-in.	pipe, weighing	1,000	lbs. each.
3,000	"	8-in.	" "	555	" "
6,000	"	6-in.	" "	420	" "

A GOVERNMENT ARMOR-MAKING PLANT is opposed in the report of Capt. Charles O'Neil, Chief of the Naval Ordinance Bureau, which has just been made public. The report maintains that the government can purchase armor more cheaply than it can manufacture it, and regards the making of armor as the proper adjunct of a commercial steel plant. Foreign practice, it is urged, is in accordance with this view, and should the government acquire a plant of its own, the report says, that it would be at a great cost and the chances are that it would lie idle a large part of the time, thus suffering great deterioration, and making the expense of operating it when needed more than offset any advantages gained by such ownership.

The newspapers continue to record the tour of investigation being made by the special government commission appointed to consider the construction of a government armor-making plant, with details of the commission's trip through the iron and steel manufacturing centers of the Southern states. It is also announced on the authority of Mr. Wm. Wharton, a large stockholder of the Bethlehem Iron Co., that his company has made an offer to sell its plant to the government at a very low price. Press dispatches also state that a similar proposition to sell its armor-making plant has been made by the Carnegie Steel Co.

THE MICROSCOPIC INSPECTION OF STEEL.

By Francis Scott Rice, Steelton, Pa.

A brief abstract of a paper read by Mr. Cunningham before the recent meeting of the American Society of Civil Engineers, on "The Strength of Structural Steels," has been noticed with much interest. Since it seems to give expression to a common desire of the engineer for better material, the following notes of experience in the microscopic examination of steel are submitted with the same result in view; believing that in the intelligent use of the microscope we may make advance certainly towards a more homogeneous product, gain all necessary knowledge as to heat treatment and safely use much higher grade steels and unit strains.

We do not even experiment in its use. Since the first paper published by H. C. Sorby on this method, in 1864, a number of other workers have studied the subject, until Mr. Stead writes:*

> It is evidently time that this branch of research should not be neglected, and that in our works, and all metallurgical laboratories, the microscope should hold a prominent if not a premier position.

With this strong endorsement the writer heartily agrees; and certainly the structural engineer has more at stake than any one else. Since the full development of structural formulas, the practice of the engineer has become a mathematical profession. From any assumed conditions of loading he calculates exactly the stresses in the various members of any required structure; the allowable unit stresses are deduced from formulas again mathematically exact, most of which are based on the elastic limit or its equivalent; which may be considered as one-half of the ultimate strength of the material. After these absolutely correct conclusions are reached, the next step may be called comical: he uses from five to ten times as much material as his formulas require! One hundred per cent. of this may and should be allowed for the above relation of the elastic limit to the ultimate strength. In view of the lives and property interests involved, it would be reasonable to add another one or even two hundred per cent., which brings our factor of safety to 4; the remainder must be directly charged to real or supposed lack of uniform quality of steel.**

It is well known that our structural steel has little care bestowed on its manufacture.† A practical steel worker answered my request for an analysis of a sample submitted for inspection with, "Analysis? That does not cut any figure. I can get you 16 different kinds of steels from a plate that many inches square!" This is the most obvious fact brought out by microscopic examination; not only the difference between various samples, but also, for instance, between the center and periphery of the same piece. In changing from the use of the old-time refined and double rolled iron to steel, we have been content with too little. Satisfied with the stronger material, the old thorough methods were abandoned, which are necessary for the strongest product, and one homogeneous throughout. Without doubt, the finishing heat also has much to do with the tensile strength; and, finally, no specification for steel is complete without stating the percentage of carbon required, which is the distinguishing feature of steel, gives all the advantage gained over iron, and is the real basis of increased strength. It may be that heretofore the engineer has had no practical way of testing the product with sufficient accuracy. In the microscope he has an instrument of extraordinary perfection, capable of recording results through photo-micrographs with absolute accuracy. It can show, first, within less than ten points (0.10%) the carbon constituent; the chemical laboratory can also do this. But it can further show the heat treatment, whether cooled slowly, quenched suddenly from a high heat, or annealed, and very closely the finishing heat; and, to some extent, the amount of working, through sizes of the crystals. The manufacturer may object to higher grade steels and increased working on ground of cost; but the engineer should have the best, and is generally willing to pay for it, if only he may gain in strength 100%, 50%, or even no advantage but the great one of reliable material.

To make the method successful requires great care in preparation of specimens; sections must be perfectly polished, and etched only sufficiently to bring out the structure. High magnifying powers are not needed, but special illuminators for opaque objects must be used; and, above all, the most careful and intelligent manipulation exercised to secure uniform results.

A brief explanation of the terms adopted to describe the various microscopical constituents of steel may be of use in understanding the figures. The differences in structure caused by different heat treatment should also be plainly distinguished.

Steels cooled as in ordinary process of working and rolling are here termed "normal"; those cooled suddenly from a heat of 1,000° C. or more, by plunging into cold water or other fluid, are called "quenched"; and those in which the same heat has been reduced so slowly that the whole mass is of practically one temperature until the cooling is completed are known as "annealed."

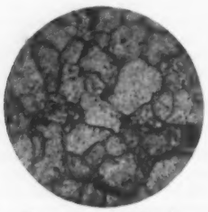

Fig. 1.—Cooled Slowly.

Fig. 2.—Quenched.

OPEN HEARTH STEEL, CARBON 0.08 PER CENT.

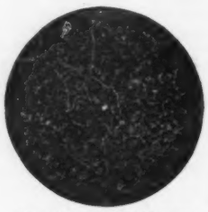

Fig. 10.—Cooled Slowly.

Fig. 11.—Quenched.

OPEN HEARTH STEEL, CARBON 1 00 PER CENT.

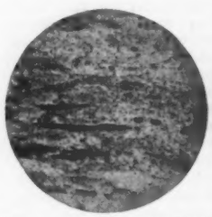

Fig. 3.—Longitudinal Section of Iron Cable Wire from Old Niagara Suspension Bridge.

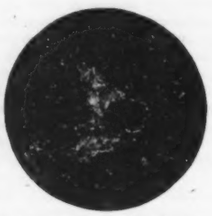

Fig. 12.—Crucible Steel, Carbon 0 97 per cent., Cooled Slowly.

As to microscopical structure, four principal and characteristic structures are recognized: Ferrite, cementite, pearlyte and martensite. All steels, neglecting minor impurities, are composed of two primary constituents, ferrite or iron, and carbon, through the addition of which iron becomes steel. Ferrite may appear alone and uncombined, and is then known as "segregated," but carbon is always in combination with iron, with the formula Fe_3C, and is then known as cementite. Cementite recombines with the ferrite to form pearlyte in all normal steels; but combines in a different proportion to form a different structure called martensite, if the specimen be heated to 800° or 1,000° C.; and if the specimen is then quenched, the martensite may be "fixed," as it were, and made available for microscopic examination.

Ferrite appears alone, of course, in iron, as in Fig. 3. In mild normal steels it generally appears in crystalline form with cementite cell walls, as in Fig. 1; and as carbon is added it combines with the resultant cementite to form pearlyte, the pearlyte increasing to 100% with 0.80% carbon; this is called the "saturation point" of iron for carbon; and with more than this percentage of carbon free cementite appears, first as brilliant metallic cell walls, as in Fig. 10; and with over about 1.30% of carbon, in segregated masses; but is always structureless. Cementite is the hardest of these four constituents.

Martensite appears in all quenched steels, differing in color from a straw color in mild steel to almost black in those of higher grade; it forms the whole mass in quenched steels containing 0.20% of carbon or more, as in Figs. 5 and 8, until the saturation point is reached, when free cementite appears, as in Fig. 11; but this saturation point for carbon is higher in martensite than in pearlyte. Little is known of the chemical or microscopical structure of martensite, although it is the key to the tool steel industry, and the most of microscopical work has been devoted to this structure to solve the problem of the hardening of steel. It is a structural condition which confers hardness on steel; which property pearlyte does not possess. Pearlyte and martensite, although both shown dark in the illustrations, are very distinct structures until the carbon approaches the saturation point, and the martensite nearly approaches pearlyte in depth of color, when more care must be exercised. But pearlyte almost always appears in good, and especially in crucible steels in its lamellar form, in alternate layers of ferrite and cementite, as shown plainly in Fig. 12. In this form it gives rise to beautiful iridescent effects resembling mother-of-pearl, whence its name; which seems to be a sort of diffraction grating effect caused by those alternate plates of different color and reflective power.

From the above, it appears that the microscope should easily detect differences of 0.10% of carbon in all normal steels.

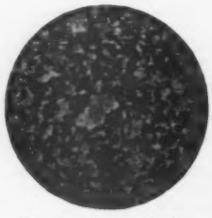

Fig. 4.—Cooled Slowly.

Fig. 5.—Quenched.

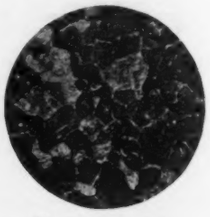

Fig. 6.—Annealed.

OPEN HEARTH STEEL, CARBON 0.30 PER CENT.

* See "Journal of the Iron and Steel Institute," London, Vol. XLV., No. 1, 1894, for this paper, and also a full bibliography of the subject up to that time.

**We must take exceptions to these statements. The calculated stresses are based on "assumed" and not absolutely known conditions of loading. Given the geometry of a truss and the steady load, we may calculate exactly the stress due to that load, but how much this stress is increased by vibrations caused by wind or by moving loads, or by changes of temperature of adjoining members of the truss as well as of the piece considered, we are ignorant, and this ignorance is allowed for in the factor of safety. Again, the allowable unit stresses are not deduced from exact formulas, but from the results of experiments.—Ed. Eng. News.

† We think that this statement is a little strong.—Ed.

In mild steels, if the specimens be quenched, the martensite rises to 100%, with 0.20% of carbon, and it would in practice be feasible to divide and distinguish 10 distinct graduations in this, each of which would represent an increase in carbon of 0.02%; at present, perhaps, few structural steels contain over 0.20% of carbon.

As to heat treatment, crystalline forms are very hard to develop unless the carbon is of very low percentage, or the specimen be annealed. Much can be learned, doubtless, through the sizes and general appearance.

In conclusion, the writer hopes that this article may excite interest and lead others less busily occupied to take up these investigations, with every prospect for successful and practical results.

The accompanying are photo-micrographs of a few samples selected to show,

First—The characteristics with respect to carbon constituent.

Second—Effect of heat treatment.

Third—Crystalline structure.

These have been taken under uniform conditions of magnification, light, plates, exposure, and development, and with no retouching of negatives. The color effects, of course, add much character in actual observation.

Fig. 1. A good specimen of very mild steel. Light crystals are ferrite, surrounded with walls which appear double in places, indicating that each crystal has its own individual and distinct envelope.

Fig. 2. Same as Fig. 1, quenched; crystals covered with what appear to be small blisters of beautiful iridescence.

Fig. 7.—Cooled Slowly.

Fig. 8.—Quenched.

Fig. 9.—Annealed.

OPEN HEARTH STEEL, CARBON 0.35 PER CENT.

Fig. 3. Iron wire from main cables of the old Niagara suspension bridge, lately replaced, after forty years' use. No carbon present, and black is so-called "cinder spots." Should show crystallization plainly, according to the theory of fatigue of metals, but crystals wholly absent.* Made in England.

Fig. 4. The light portion is ferrite, with lamellae faintly shown in large central mass; pearlyte is dark. Theoretically should be composed of about 37% of pearlyte to 63% of ferrite.

Fig. 5. The whole mass is martensite.

Fig. 6. Crystals apparently divided between ferrite and pearlyte structure; walls are ferrite.

Fig. 7. Theoretically should be pearlyte 65% to ferrite 35%. The darker portion as shown, is the ferrite as left by etching, and without polishing on chamois, which would turn it white and brilliant, as in Fig. 1. Signs of lamellae in lighter portions of pearlyte.

Fig. 8. Whole mass of martensite considerably darker in color than in Fig. 5.

Fig. 9. Crystals not wholly distinct, and have not succeeded in developing any crystals in higher grade steels than this.

Fig. 10. Hard tool steel; pearlyte masses are surrounded by brilliant metallic cementite walls.

Fig. 11. Martensite masses surrounded by cementite walls, the latter almost absorbed through the higher saturation point of martensite for carbon.

Fig. 12. Pearlyte, with small segregated points of cementite, the lamellar form of pearlyte showing plainly in center. Specimen was hammered as well as rolled, and is a very fine high grade crucible steel.

Specimens grouped together were cut from the same bar and supposed to be of identical chemical composition. The original photo-micrographs show fields actually 1-100 in. in diameter, and the magnification was 200 diameters, which has been slightly reduced in the process of making engravings from the photographs.

*We understand that the theory of "fatigue of metals," or the "crystallization" theory does not hold that iron subjected to repeated stresses for forty years or more will necessarily become crystalline, but only that it will become so if the stresses are beyond the elastic limit. There is no evidence that the wires in the Niagara bridge were ever subjected to such stress.—Ed. Eng. News.

POWER DISTRIBUTION AND MULTIPHASE CURRENT TRANSMISSION FOR STREET RAILWAYS.*

By Maurice Hoopes.†

Aside from the demands of what is usually considered steam railroad service, the business of the ordinary urban and suburban railways has grown lately in a way that requires some means of augmenting the usual method of power distribution. Lines have been extended to greater distances from power stations, and traffic has increased on lines which always have been remote from their points of power supply. These conditions have arisen at places where disadvantages of location or lack of sufficient load would render additional power stations unprofitable. To meet such demands, several methods have been devised. The consideration of the comparative merits of these systems is the principal purpose of this paper. Before undertaking this task, however, the writer desires to discuss some of the conditions met with in the operation of the ordinary 550-volt distributing system. Some of the points raised have been frequently made. For these an apology is offered in advance, the excuse being that they are sufficiently important to bear reiteration.

The usual electric railway distribution system, with its copper network as one, and its iron network as the other half, offers rather more complicated problems than does the ordinary form of all copper circuits. The latter system is symmetrical, whereas the former is likely to have greater resistance in the copper than in the iron portion. A rule that holds good of both systems is that the maximum benefit in reduction of total resistance, due to the addition of a given amount of conductor, results when the addition is made to the parts in which the drop is greatest per unit of length. An observance of this rule is important in adding to distribution systems. This demands a careful analysis of existing conditions. Before adding feed wire to a railway circuit, it is important to know the drops, under usual load, of the parts of the circuit. These may be found by the use of pressure wires, or by short circuiting the trolley wire to the rail, and passing a given current through the circuit, measuring the total drop and deducting the calculated overhead resistance from the total resistance thus found. Private telephone lines serve the purpose of pressure wires to measure track drops, and public lines connected through the exchange may be used without interference with the service. An exception to the general rule, that the copper should be added to the part of the circuit showing the greatest resistance is the case of a poorly bonded track that may show less resistance than the overhead. Re-enforcing such track with overhead copper connected to each end of all special work may result in the greater decrease in the total resistance of the circuit. This is really a special application of the general rule, rather than an exception to it, however.

Means for regular and easy measurement of track joint drops should exist. For tracks having frequent high resistance joints, there is no better way than walking over it with a low reading volt-meter connected to prongs on the end of a stick, that it may be bridged across joints. For detecting poor joints in good track, where they are far apart and for the general inspection of the condition of track wiring, a car is convenient. A box trailer with each wheel insulated from all others, and a volt-meter connected between the two wheels on each side of the car may be used. A third meter connecting the two opposite wheels will indicate defects in cross bonding. The writer considers that it is unnecessary to complicate the measurements by attempting to measure the resistance of the joint. His experience is that, if a bond is loose enough to have abnormal resistance, it will get worse rapidly, and show excessive drop with even small amounts of current. It behaves very much as did the fellow's little girl, and is either "very, very good," or "horrid."

It is universally recognized that the maximum efficiency is obtained from a distribution system when it is operated as a whole, and not divided into sections. The liability of accident to railway trolley wires make it necessary to separate them in such a way that trouble at one point will not block the whole road. These sections should be as few as possible, while accomplishing the purpose for which they are designed. Where one road has two or more power stations, the sections approximately equidistant from each of the two stations should be connected with both. They may then serve to equalize load between stations, the common section being cut loose from the station needing to decrease load. Two feeders to such a section, one from each station, constitute a tie line between stations. If desired, the potential may be raised in one station to a point that will deliver current into the other. Unless the drop in the combined feeders is excessive, it will probably be safe to allow the section attached to take the increased potential. Tie lines between stations which serve none but emergency purposes, are expensive, especially if the stations are distant from each other.

Where the ordinary methods of distribution are not applicable because of the prohibitive amount of copper necessary, some one of the following systems is commonly used to care for the particular section:

1. A "special generator" run at increased voltage and usually overcompounded as much as possible, handling the section and no other load.

2. A "booster," consisting of a series wound generator, connected in series with the feeder as it leaves the main station bus. The field turns of this generator should be such as to make the e. m. f. of the armature as nearly as is possible equal to the drop in the feeder, throughout all ranges of current.

3. The "three-wire system." This requires the division of the section into two. One-half is then supplied from the regular bus, and the other from a special generator, with the polarity reversed, to bring the trolley wire opposite in potential to that of the rest of the system. The trolley wire should be so divided into the two half sections as to leave, as nearly as possible, equal loads on the two at all times. With this arrangement, the current in the track is only that flowing from the cars on one half section to those on the other. If these half sections are located near each other, this path through the track is very short. For this reason it is usual to make one track of a double track road one half, and the other track the second half section. Unless conditions are such that the cars are likely to be bunched on one track this seems the better way of dividing. In addition to conducting current between cars, the track has to conduct back to the power station the excess in current used on one half section over that used on the other.

4. The "alternating current transmission system." The only form of alternating current system desirable for railway work consists of high voltage, multiphase generators (or low voltage generators with step-up transformers) in the main station connected with one or more substations containing step-down and rotary transformers. There are some half-dozen such systems in use in this country, of which the best known are those from Lowell to Nashua, and from the station of the Niagara Falls Power Co. to Buffalo.

With any of the foregoing systems, the storage battery may be applied as an auxiliary. In a railway power station, a battery is useful to the extent that it improves the station capacity and fuel economy by removing the immediate fluctuations. The writer considers that there are few instances where a battery can be installed, with resulting profit, where its function is the storing of power one hour for use the next. Except with very short time peaks, the battery costs as much as the additional generating apparatus. Particularly in small stations, however, there is such a variable load that it is impossible to average full load from the station for a period of time, because of the inability to handle the very great short-time overloads that such an average load demands. In such a station, a battery may result in a considerable increase in station capacity, and by allowing the engines to operate at practically constant loads, reduce the fuel consumption greatly. While a battery may do these things in the station, it may do even more remote from the station. In the latter location, it will keep the potential near it practically constant, and will also maintain uniform current flow between the station and the particular point, thus adding the advantages of regulation and greatly increased copper efficiency.

One side of the story makes a pretty good case for the storage battery; unfortunately, the other must be told. The first cost of a battery is so very great that reasonable interest and depreciation on the amount invested will more than consume the apparent saving in many cases. Especially is this so in the case of a battery located on the line, where it has been shown that the gross saving is the greatest. This is true because it requires a very much larger investment in battery to care for the load

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† Electrical Engineer Lynn & Boston R. R. Co., Lynn, Mass.

variations of a given station if the batteries must be divided up among several substations, the load factor of each of which is necessarily lower than that of the main station. The sum of the maximum variations of the several stations is always greatly in excess of the maximum variations in the main station. If, however, a power station were to be located at a considerable distance from a single center of distribution, through which all feeders from the station passed, it is quite probable that a battery placed at the latter point would result in a net saving, due to its giving each, the station and copper, an uniform load.

When it becomes necessary to select from the foregoing list the most suitable system for a given case, there are many conditions to consider in the decision. Either of the first three, the special generator, the booster or the three-wire system, may be arranged with the apparatus in any railway power station, assuming that it includes a reserve generator of the necessary size. It is better to use standard railway machines for these purposes, and, if possible, to arrange the station so that any one of the regular station machines may be used. It frequently occurs that one or more sections of line fed from a certain station have copper enough leading to them to care for them properly at all times, excepting a few hours on each ordinary day, and for longer periods on heavy days. While the work may be quite variable at times of light load, when the load increases it becomes more nearly uniform. Such sections may be satisfactorily supplied over the copper designed for the lighter load, by raising the voltage on the station end of the feeder during heavy loads. Usually, the margin in the field rheostat will allow the increase of voltage on any one of the generators, to a point considerably above the normal. When this is not so, it is possible that the generator speed may be increased, unless limited by the requirements of safety in the driving engine.

In one or both of these ways, it is often possible to get from 700 to 750 volts from a standard 550 volt machine. This increase enables the heavy load on the section to be handled very satisfactorily. The voltage at the feeder end necessarily varies with the load, and with ordinary fluctuations there may easily be 100 volts difference between the minimum and maximum. A recording volt-meter placed at the feeder end will show a very inky piece of paper, after a run. In practice, on a line which the writer finds it necessary to handle in this way, he gets variations from 450 to 550 volts. The minimum is infrequent, however, and the schedule is made apparently as well as though the potential were absolutely uniform. Considering the question of abuse of apparatus, the increased voltage is not likely to injure a generator of modern construction. Practically, the only additional care that seems necessary is of the generator fields, noting that the increased current in the shunt windings does not heat them above safe temperature. So long as the potential at the car stays under 600 volts, there is little probability of trouble with equipment. Although the writer has had no such experience, he has known of cases where higher voltages have caused the arcs at controller contacts, when breaking, to jump to the iron frames. This difficulty has been experienced more particularly on small roads using boosters, where one car might constitute the entire load on the booster. At times of throwing off the power, the booster holds up its potential for a sufficient time to result in a very greatly increased voltage during the time of the controller opening.

The method just described has the advantage of simplicity and economy. Cases arise, however, when the very great fluctuations in load make its use impracticable. With a line which, at certain times, carries very heavy current, as compared with the average, there must be some means of automatically raising and lowering the voltage at the station end of the feeder, to properly compensate for the variable drops. To accomplish this, a booster is used. As has been said, this machine is a series wound generator, connected in the feeder as it leaves the main bus, and so proportioned that a given current through it will give sufficient field strength to induce an e. m. f. in the armature equal to the fall of potential which the same current causes in the feeder. In practice, this condition is only approximated. Were the generators to have a perfectly straight characteristic curve, of proper pitch to match that of the feeder drop, the feeder and potential would exactly coincide with that of the power station. The curves of all dynamos droop away towards the horizontal as the magnets approach saturation. This results in the booster failing to compensate wholly for drops of current above a certain amount. In practice, however, boosters are used which raise a feeder potential to 1,000 volts, and care for variable loads without allowing the light load voltages to rise, at the feeder ends, to dangerous amounts. The system has the advantage of caring for extreme overloads on particular feeders, and is useful in cases where, for short periods of time, the feeder is such as to cause excessive drops, and the time is not great enough to justify increased copper investment. On the other hand, it is expensive in operation, due to the fact that it wastes considerable energy, and that it generates this wasted energy in rather an extravagant way. If the booster is engine driven, the engine has widely fluctuating loads to handle, the load varying as the square of the current in the feeder. These variations necessarily result in a very low economy for the engine. With a motor-driven booster, there are the constant losses of the two machines to meet. These are not so great as those of the engine and booster, but the necessity of keeping a particular generator for use as a booster limits the flexibility of the arrangement as compared with one which permits the use of any of the regular station generators, and, moreover, the addition of a motor booster does not increase the capacity of the station, as the power to drive the motor must come from the engines. The compounding of the standard types of railway generators is usually such that, when full load current is passed through them, the series turns alone will raise the fields to a point that will induce nearly normal e. m. f. in the armature. This adapts the machine for use as a booster on almost any line, excepting one requiring more than 100% increase of potential at times of full load. As lines when so overloaded would be much better provided for by the addition of more copper, they need not be considered. In most cases, it is necessary to cut down the e. m. f. of the standard generator in order to secure the proper ratio of e. m. f. to current for boosting, and this may be done by decreasing either its speed or the number of field turns. The former method has the advantage with an engine driven unit of improving the engine economy by lessening the friction losses and keeping the cut-off at a less wasteful point, whereas, the latter is the simpler way. To accomplish this, the writer uses a long German silver strip of sufficient section to carry the proportion of current that it is desired to shunt out of the fields. This strip is fastened to the generator frame, connected across the terminals of the series field, and doubled on itself in such a way that a clamp may be slid back or forth on it, raising or lowering its resistance. Knowing the resistance of the feeder upon which the machine is boosting, the clamp may be shifted to the point where the ratio between the reading of the voltmeter and ammeter is equal to the feeder resistance, and the proper adjustment reached.

For temporary uses, it is possible to make the necessary switchboard connections with flexible cables as the only adjuncts to the apparatus on the regulation board. A cable which may be attached to the positive lead of any of the generators, at the switchboard, and to any feeder, answers the entire purpose. With some boards, it is only necessary to have terminals on the cable that may be inserted into switch jaws. If the generator leads and the feeders happen to terminate into switch blades instead of jaws, the cable must have its ends fitted to clamp quickly to these blades. With this preparation in order to transfer a particular feeder to a special generator for the purpose of increasing the voltage upon it, the cable should be attached to the positive generator terminal, the other end hung convenient to the feeder switch, the generator built up already for use, the feeder opened and attached to the cable, and finally, the circuit breaker and negative generator switch closed. If it is desired to extend this system to booster working, it is necessary to have a second cable leading from the positive bus bar and capable of connection to the negative terminal of the booster. It is best to include a circuit breaker in this cable to protect the booster, as the regular generator circuit breaker will be cut out.

At best, however, cables are troublesome appliances and allow only comparatively slow transfers. Moreover, it is impracticable to arrange cables so that two generators may be run in parallel on the special high voltage service.

In a modern station of few large units, it is improbable, were the necessity for booster service to exist, that one of the large generators could be spared or would be desirable for the purpose. In such stations, however, it is usual to install a smaller machine to carry the all-night and other light loads. This machine might be relied upon for the booster work. If the engine driving it has its governor arranged to adjust for a large variety of speeds, both above and below normal, and the unit be designed to run safely at the increased speeds, the combination will be found very convenient for meeting all classes of demand. The speed may be dropped for booster working, and raised when the generator is run at high voltage on a particular feeder. With this arrangement of dependence upon an individual unit for the special service, it is, of course, unnecessary to equip the whole switchboard with the extra negative bus. The double positive bus will be found convenient in any station, however.

The "three-wire system," although very useful in lighting work, has been of little service in railroad distribution. Its value for the latter purpose has been considerably overestimated, although there are places where its use has resulted in the maintenance of satisfactory potential on sections of track, using the same copper, when the usual system could not approach doing it. The advantage of the three-wire system is based on the fact that it enables the use of double the usual potential for distribution, thus in the perfect case requiring but one-fourth the copper to transmit a given current at a given loss.

This law, that the amount of copper varies inversely as the square of the potential, is due to the fact that doubling the voltage halves the current for a given amount of energy. The same percentage of loss allows a loss of twice the number of volts, and this, with but half the current, admits of the use of copper having four times the resistance, hence one-fourth the weight. The "perfect case" just cited is one in which no third or "neutral" wire is necessary. Such a one does not exist in practice, and this neutral wire has to be supplied to conduct the excess of the current used on one side of the system over that used on the other, between the generators and the motors. In railroad work the rail is used as the neutral conductor. It is seldom that a whole road is operated on this system, the common practice being to apply it to only those parts on which the ordinary system is insufficient. Where there are but one or two sections to operate with the reversed potential, the switchboard described may care for them satisfactorily. If one generator is made to build up with reversed polarity, and is coupled into the auxiliary bus, it will handle such feeders as may be thrown upon it as the negative side of a three-wire system. The generator may have its residual charge reversed in a number of ways, one of which is to have the shunt field wired through a double throw switch on the machine, arranged to disconnect the field coils from the armature and connect them in the reverse direction to a pair of charging wires fed from the switchboard. The machine may have its residual charge brought back to the usual direction by the commonly used means of throwing in the positive and equalizing switches, with the negative open, and allowing the current shunted from the series coils of the other machines to energize its series coil. Where three-pole switches are used on the generators, the shunt field double-throw switches may be omitted, and the field reversed through the series coil by using an X-shaped pair of contact pieces insulated from each other at the point of intersection. These may be pressed against the switch jaws in such a way as to reverse the current shunted from the other series coils through that of the machine to be reversed. Where the three-wire system is the regular system of operation, and the sections are divided equally between the two sides of the system, a regular three-wire board is preferable. For a less general use of the system, the method described answers as well. The arrangement then becomes the same as that of the "special generator," with the polarity reversed, and the potential on the machine may be raised above normal, and the advantage of greater allowable drop in the copper added to that of the saving in track drop, due to the reversed current flow.

The writer has said that the value of the three-wire system in railroad service has been considerably overestimated. This statement probably needs explanation. In lighting work, the three-wire system saves 62% of the copper. Each wire has to be but one-fourth as large as with the two-wire system, but it is usual to make the neutral of the same size as the other wires, thus requiring three wires, each of one-fourth the size of those of a two-wire system; hence the use in the three-wire system of three-eighths, or 37½% of the copper necessary in the two-wire system. Because this is true of lighting work, it is often assumed to be true of railway work. It is not, however, and in no case where the track renders any appreciable service as a conductor, can the saving from the adoption of the three-wire system approach the above figures. In general, its use will make a gross saving of the loss in track (assuming that there is no copper paralleling the track that may be used as a positive feeder). The net saving will be this gross loss in track less the track losses due to the passage of current from car to car, and of the excess of current due to lack of balance, back to the power station, and the increased overhead loss due to the greater drops in the divided feeders than in them when combined. The only conditions where the method seems to be applicable, are those of excessive track losses with fair opportunities for balanced load. Such a case existed on the Lowell & Suburban road. They have a heavy business over a double-track line to their park, some six miles from the power station. By changing to positive feeders those formerly used as overhead returns, and operating the line as a three-wire one, they very greatly improved the efficiency of the distribution system.

In the selection from the various systems of distribution, of the one best adapted to a particular instance, there is always a large number of variable factors to consider, and usually more or less speculation as to the values of certain ones on which no accurate data are accessible. This makes it impossible to work from fixed laws, and demands individual consideration of each case. For these reasons, there is considerable room for divergence of opinions in the matter. The writer has given his ideas as to the comparative infrequency of cases in which the three-wire system is desirable. The booster has a very much more general application, and is suited to a greater number of cases than in any one of the other systems. Nevertheless, wherever work can be handled by a special generator, it should be, unless the change involves abandoning existing apparatus. The last method saves considerable over the booster, and is preferable for its simplicity. The only limiting condition to its use is satisfactory regulation. The alternating current system,

with rotary converter substations, competes with the booster system and special generator in cases where the load factor (the ratio of average to maximum load) is high, and where the regular 500 volt transmission will suffice during only a few of the twenty-four hours. In such a case, the copper losses, because of the length of time during which they are excessive, are so great that they may often exceed the entire expense of an alternating transmission system. The latter system also enters into competition with the independent power station for that class of business that is too remote from an existing station to admit of satisfactory handling by the other transmission methods, and too small to furnish load for such a station as may approach in economy the station from which the alternating transmission would be operated. Cases of each kind arise with city roads in their needs for transmission to suburban centers of load, and with interurban roads. The roads which the city station receives from the surburban centers have usually a very low factor. At morning and night they are excessive, and through the remaining hours comparatively light. Were an alternating transmission system installed for such use, it would probably lie idle for a large part of the time, its copper being used to transmit direct current. During the heavy hours it could be called into service. This same service might be rendered by raising the voltage on the direct current feeders by use of the special generators, and allowing the loss, which has been from 5% to 10% during the light load, to become 25% to 30%. In this way, the line may carry three or four times as much current, and maintain the voltage at the distant end.

In comparing the system, it is necessary to compute the annual cost of each, including the items in the following list:

Alternating Current.	Direct Current.
Fixed charges and repairs on main station static transformers, if any, and on substation static, and rotary transformers, and accessories.	Interest, depreciation, and repairs on such increased cost of engines and generators, as is occasioned by their being fitted to furnish increased voltage.
Fixed charges on substation land and buildings.	Cost of fuel to produce output representing difference between losses in direct current feeders and those in alternating current feeders and transformers.
Substation labor.	

This assumes that the same amount of copper is used in each system, that the alternating system does not remove the need for sufficient copper to handle the load with direct current during a part of the time, and that this amount of copper will suffice for heavy loads by means of the increased direct current potential transmission. Should the load be of such a nature that the alternating transmission would be operated throughout the whole time, there may be a correction made in its favor of the annual cost on the increased amount of copper necessary for the direct current system over that for the alternating system. It is probable that the direct current generator and engines need not be increased in cost more than 10% by the requirements of the increased voltage. The writer has said that he is operating satisfactorily with machines designed for the standard voltage. Points which should be made against the alternating current system, which cannot be given exact money values, are the danger to life from the increased voltage, lack of uniformity in equipment, making lack of flexibility in stations (where, under the other arrangement, any generator may serve any demand), and the danger of delays due to the increased complication of the system, it sometimes requiring fifteen or twenty minutes to start the substation machinery and get it into service after it has been stopped in the midst of load by accident. These points of disadvantage are very important ones, and operating companies can well afford to expend considerable money to avoid them. Especially is it undesirable to install for railroad work a system which may be disturbed by the extreme overloads such work introduces, and which cannot be restored to an operative condition immediately the load is brought within bounds. With the rotary transformer system, any short circuit or extreme load, which is not relieved by the substation direct current circuit breakers, may stop the rotaries and shut the power off the line during the long interval it takes to start them and put them into service.

In the comparative estimate, the results depend more upon the load factor than any other condition. With it sufficiently high, the alternating transmission may show an economy over the direct current for areas within a very few miles of the power station. Unfortunately, however, the yearly load factor is usually very low on railroad work. With such a condition, it is cheaper to have excessive losses in copper at times of heavy loads than to carry the necessary equipment of alternating transmission apparatus to keep the losses down at such times. The railroad manager naturally insists that the voltage be maintained reasonably near its normal value over the whole road at times of heaviest business. Estimates that show immense costs for copper to accomplish this under the regular distribution system make him turn to the consideration of additional power stations and multiphase transmissions. If he can be shown that he may care for his maximum loads over the existing copper by simply raising the voltage on the station end of the sections of heavy loss, and pay for the loss with coal instead of with interest and depreciation on a great amount of additional machinery, he is likely at least to determine carefully which he can better afford to do. While, in the writer's opinion, the majority of cases may be best handled by direct current distribution, there are many instances of need for a distribution system where none but the alternating current system is applicable. Where water powers are used, they are almost always so remote from the center of load that very high potentials must be used for economical transmission. Long interurban roads operating so few cars that load can be had for only one power station, bring a condition where distribution must be so accomplished by substations, on the alternating system. The Lowell transmission presents a case where it was a problem whether to care for the new territory with a separate station, or to transmit from the existing station. So much has been written about the multiphase current system that was decided upon and installed there, that it is unnecessary to attempt a description of it. Mr. Sullivan, the general manager of the company, has kindly furnished the writer with a copy of the estimates from which the choice of systems was made. He states that operation justifies the estimate in its statement of the cost of the multiphase system. It showed the cost of power delivered to the trolley wire to be, for the transmission system, 70% of that for the separate power station. There were no figures showing what this work could have been done for with a booster system. Inasmuch as the latter method has been used successfully in place of the other, temporarily, it would be interesting to know its comparative cost. Tests of the Lowell system extending over eighteen days show an all-time efficiency of 76% as measured from alternating generator output to rotary converter output, the losses being those of two sets of static transformers, line and rotaries. The maximum efficiency for any one day was 73%. The voltage regulation at the substation is about equal to that of a well-governed steam-driven power station.

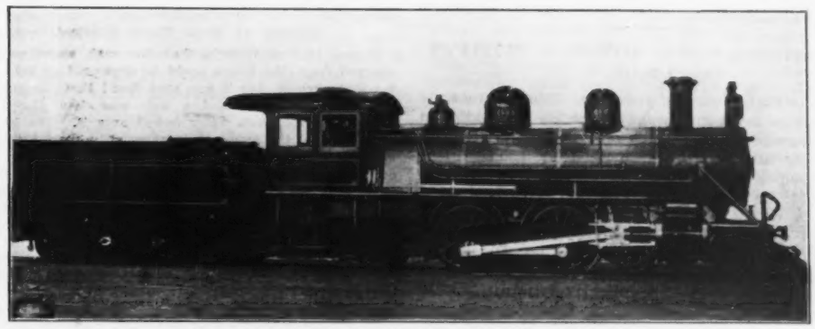
The writer has said that the use of alternating currents for ordinary electric railways is limited to the rotary converter system. This is due to the fact that alternating current motors, in their present state of development, are not adapted to the needs of such railways. As yet their use for traction purposes is limited to a few European roads, of which the best known is in Lugano, Italy. Alternating motors have the disadvantages of limited torque and tendency to synchronism. This makes them poorly adapted for the uses of any line but one having long runs at practically uniform speeds, and few stops. These conditions are those of a through express service between cities. Accommodations and ordinary street railway services are such as can only be handled satisfactorily by direct current motors. At first notice, this fact seems rather contradictory to one's ideas of the flexibility of alternating currents. The ideal system has been thought to be one composed of a generating station containing large multiphase generators, with lines distributing current at a potential high enough to require but a comparatively small amount of copper, static step-down transformers, and motors that may be regulated throughout all desired variations of speed by merely changing the impressed e. m. f. with a controller depending upon the use of various ratios of transformation. This dream included the freedom from the care of commuters, and pictured a car equipment that would need a minimum of attention. Were it possible to realize all of these advantages, it is probable that the somewhat serious complication introduced by the necessity for two trolley wires might be tolerated. There seems to be little probability, however, of an early solution of the problem of adapting the alternating motor to the intermittent work of the street railway.

In conclusion, the writer desires to say that the title of this paper may have led some to expect rather more particular attention to the multiphase transmission system, and less about direct distribution. He has, however, given the various systems the same relative importance in the paper that he considers them to have in application. Hence, the subordination of the alternating current system in the consideration of the general subject of power distribution.

AN AMERICAN LOCOMOTIVE FOR SOUTH AFRICA.

We show herewith a view of a locomotive built for the Cape Government Railways, of South Africa, for photographs and particulars of which we are indebted to the builders, the Baldwin Locomotive Works, of Philadelphia, Pa.

The engine is one of six, intended for passenger service, and designed to consume an inferior quality of coal as fuel. They are for a track of 3 ft. 6 ins. gage, which is the standard gage of railways in South Africa. They are of the Atlantic type, resembling somewhat an eight-wheel engine, but with the driving wheels set forward of the firebox, and having a small pair of trailing wheels under the firebox, so that the engine has ten wheels, only four of which are driving wheels. The engine is of distinctly American appearance and is equipped with pilot, circular headlight, extension smokebox, etc., but it has no bell, and the brake hose is not for the Westinghouse brake, but for the English automatic vacuum brake. The crosshead is deep and of the "alligator" pattern, with two slide bars. The rear driving wheels are the main drivers, and the connecting and side rods are all of I section. In the equalizing arrangement it will be seen that the rocker over the trailing axle box is connected by hangers, with the driver spring equalizer and with an inverted semi-elliptical spring seated under the rear end of the main frame. The tender has channel iron frames and is carried on two passenger trucks, with inverted semi-elliptical springs, seated on the equalizers. The general dimensions of the engine are as follows:



PASSENGER LOCOMOTIVE FOR THE CAPE GOVERNMENT RAILWAYS. (SOUTH AFRICA.)
Baldwin Locomotive Works, Builders.

Passenger Locomotive; Cape Government Railways.

Running Gear:	
Driving wheels, diameter	4 ft. 8 ins.
Truck wheels, diameter	2 " 4 "
Trailing wheels, diameter	2 " 9 "
Tender wheels, diameter	2 " 9 "
Engine truck	Swing bolster.
Journals, driving axles	7½ × 8 ins.
" truck axles	5½ × 8 "
" trailing axles	6½ × 9 "
" tender axles	4¼ × 8 "
Wheel Base:	
Driving	6 ft.
Truck	6 "
Total engine	22 ft. 6 ins.
Total tender	13 " 2 "
Total engine and tender	45 " 8½"
Center of truck pin to center leading driver.	7 " 6 "
Weight in Working Order:	
On driving wheels	51,800 lbs.
On truck wheels	25,400 "
On trailing wheels	21,800 "
Engine, total	99,000 "
Tender, total	63,000 "
Engine and tender, loaded	162,000 "
Tender, empty	29,590 "
Of full coal capacity	9,468 "
Of full water capacity of tank	24,002 "
Cylinders	16 × 22 ins.
Distance center to center	5 ft. 7 "
Distance center to valve face	1 " 3¼"
Piston rod, diameter	2¾"
Form of crosshead and guides	Double-bar.
Connecting rod, length between centers	9 ft. 6 ins.
Valve Gear:	
Ports, steam	1¼ × 16 "
Ports, exhaust	2½ × 16 "
Slide valves;	lap, ¾-in.; lead, 3-32-in.
Slide valves; Maximum travel	5¼ ins.
Boiler—Type	Straight top.
Diameter of barrel inside	4 ft. 8⅝ "
Thickness of barrel plates	9-16-in.
Thickness of smokebox tube plate	⅝-in.
Height from rail to center line	6 ft. 11 ins.
Length of smokebox and extension front	5 " 6 "
Working steam pressure	180 lbs.

Firebox:	
Length, inside	6 ft.
Width, inside	5 "
Depth at front	4 ft. 5½ ins.
Depth at back	4 " 2½ "
Thickness of side plates	½-in.
" back plate	½-in.
" crown sheet	⅝-in.
" tube sheet	⅜ and ½-in.
Grate area	30 sq. ft.
Staybolts, diameter	4-ins.
Staybolts	diameter, 1⅛ ins.; pitch, 4 ins.
Water space, width	front, 4 ins.; back and sides, 3 ins.
Tubes	Material, brass; No., 189
Thickness	Nos. 12 and 13 W. G.
Diameter	inside, 1.782 ins.; outside, 2 ins.
Length between tube plates	14 ft. 9¾ "
Pitch	2¾ "
Total fire are of tube openings	2.34 sq. ft.
Heating Surface:	
Ratio to grate area	51.995 to 1
Ratio of exterior tube area to firebox htg surf	14.89 " 1
Tubes, exterior	1,461.70 sq. ft.
Firebox	98.15 "
Total with exterior tube area	1,559.85 "
Miscellaneous:	
Exhaust nozzle, diameter	2¾, 3 and 3¾ ins.
Smokestack, smallest diameter	16 "
Smokestack, height from rail to top	12 ft. 8 "
Capacity of tank	3,000 gallons
Capacity of coal space (heaped up)	6 tons.
Brake fittings	English automatic vacuum.
Tractive force per lb. effective press. on piston	100.57 lbs.
Total tractive force with effective pressure = 4-5 of boiler pressure	14,482 "
Total adhesive tractive power at ¼ of weight on drivers	12,950 "

BACTERIAL TEST OF MECHANICAL FILTERS AT LORAIN, O.

The State Board of Health of Ohio has recently come to the front as one of the leading bodies in matters pertaining to the sanitary phases of water supply and sewerage. Backed by efficient legislation—a backing that some other State Boards would be glad to have, but are compelled to do without—it now exercises a comparatively rigid supervision of water supply and sewerage improvements in Ohio. The last number of the "Ohio Sanitary Bulletin," published monthly at Columbus by the Board, contains a "Report on the Mechanical Filtration of the Public Water Supply of Lorain, O.," from which the following has been taken.

Lorain is situated on Lake Erie, at the mouth of Black River, seven miles below Elyria. Its population in 1890 was 4,863, but the recent erection of the large steel plant of the Johnson Co. has added largely to the population, which is now believed to be 10,000. Elyria now has a population of about 7,000. The sewage of each city is discharged into the river.

The water supply of Lorain (introduced in 1884, by the town—Ed.) was, until 1895, taken from Lake Erie, at a point 1,200 ft. from the shore line, and a few hundred feet west of the mouth of Black River. The prevalence of typhoid fever after the discharge of sewage from Lorain into the river, led the water-works board to apply to the State Board of Health in 1895 for an approval of an extension of the intake 310 ft. further into the lake. Approval was withheld, pending investigation, the Health Board not being satisfied that the proposed new intake would avoid the sewage contamination. Apparently the intake was extended, although the report does not say so definitely.

In June, 1896, application was made to the State Board of Health for approval of a proposed contract with the O. H. Jewell Filter Co., of Chicago, for a mechanical filter plant, the plant to be subjected to six months' trial before acceptance by the city (and to remove 97% of the bacteria in the applied water, this guarantee not to apply when the number of bacteria in the effluent falls to 200 per cu. cm.—Ed.). The change in supply was approved, subject to the results of the trial.

In April, 1897, the water-works board submitted to the State Board of Health reports relating to the operation of the filter plant from Dr. A. J. Baumhardt, City Bacteriologist, and Mr. Arthur Brown, Chemist for the contractor. The Health Board decided to have independent tests made and instructed its secretary, Dr. C. O. Probst, to arrange for the same and submit a report on the results obtained. Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., of New York, was engaged as consulting engineer, and the filters were tested for five weeks, or from June 13 to July 17, 1897, under his instructions, by Mr. F. S. Hollis, of Boston, assisted by Mr. B. H. Flynn, of Columbus.

Mr. Hazen's report opens by describing the pumping plant and the various points considered in figuring, from the pump counter records, the amount of water filtered during the tests.

At the time of the test the plant was being operated by the contractor, not having been accepted by the city. The plant includes six filters, each 17 ft. in diameter, and having an effective filtering area of 226 sq. ft., or a total of 1,356 sq. ft. The filtering material is 4 ft. deep and consists of sand from Red Wing, Minn., having an effective size of 0.4 mm. (0.014 ins.) and a uniformity coefficient of 1.7, the grains being smooth and nearly spherical in shape. The rate of pumpage to each filter is controlled by a butterfly valve operated by a float on the water in the filter. A "reasonably constant rate of filtration" is maintained by a float controlling the outlet valve.*

The balance of Mr. Hazen's report is as follows:

On June 18 the alum pump was out of use, for repairs to connections, for three hours, and water was filtered without the addition of alum. On June 28, at 11.30 p. m. the pipe from the Gordon and Walker pumps to the filters burst, and repairs were not completed until 2 p. m. of June 29. During this interval of 15 hours unfiltered lake water was pumped to the city. No samples were taken for bacterial examination during or immediately after this condition.

Amount of Wash Water Required.

It was at first thought that the wash water as discharged from the filters could be measured in tubs set for that purpose, but it was soon found that the quantities were too large, and a weir was then placed so that all of the wash water flowed over it. The height of water on this weir was taken at minute intervals during representative washings, and the quantity required for each washing calculated. Forty-one washings were thus observed, and the quantities of water used for the other washings were estimated to be the same as the average of those observed. The average number of filters washed per day was 14. The time required for washing was from 4 to 12 minutes, averaging 8½ minutes. The average amount of water used for washing one filter was 8,200 gallons, or about 1,000 gallons per minute for the time of washing. The greatest ordinary rate of draft during the washing was 1,500 gallons per minute. The quantity of water used for washing was equivalent to a solid column of water 5 ft. deep and of the same area as the effective filtering area of the filter. The reverse rate of washing, 1,500 gallons per minute, is equivalent to 6.7 gallons per minute per sq. ft. of area, or about six times the rate of filtration ordinarily used. The wash water amounted to 5.1% of all the water pumped from the lake, and to 5.5% of the output of filtered water available for the use of the city.

Sulphate of Alumina Employed.

The sulphate of alumina used as a coagulant was analyzed by Prof. N. W. Lord, of Ohio State University, who found it to contain 44% of water of crystalization. The sulphuric acid, reckoned as SO_3, was 37.4%. It is what is known as Natrona alum, and of the grade commonly used in mechanical filtration.

This alum was weighed out into large tubs at intervals and dissolved in water which was then pumped through a small meter into the water approaching the filters, the amount applied at any given time being regulated by the speed of the pump. A record was kept of the amount weighed out each day and of the stock on hand at various times, and of the amounts bought, which accounts agree substantially. The quantity of alum per gallon was calculated from the amount used each week, reckoned upon the water pumped by the Gordon and Walker pumps, with 10% allowance for slip, less such amounts of water as were used without filtration and as were filtered without the use of alum.

Quantity of Alum by Chemical Analysis.

When sulphate of alumina is added to Lake Erie water before filtration, it is decomposed, and the alumina is precipitated and retained by the filter. All of the sulphuric acid passes through with the effluent and the sulphuric acid is increased over that in the lake water by the amount added. It was found possible to determine the amount of sulphuric acid added to the water in this way with great accuracy, and tests were made in this way regularly at least twice each day during the period of the tests, and the quantities of sulphate of alumina corresponding to this increase in sulphuric acid were calculated and compared with those calculated from the weights.

These results show that the amount of sulphate of alumina added varied considerably. In the first three weeks it was found that the quantity of sulphate of alumina added to the water varied from 3.9 to 2.1 grains per gallon, and in the last two weeks the quantities ranged from 1.7 to 0.8 grain per gallon. These very wide fluctuations in periods when the quantities were intended to be constant suggest the desirability of improving the apparatus for controlling the amount of alum.

For the whole period the quantity of sulphate of alumina shown by the increase in sulphuric acid was 10% greater than that calculated from the weights. This discrepancy may be accounted for by a greater pump slip than that assumed, or by the use of more alum during the day than during the night (chemical samples were taken in the day time only), or by errors of analysis, or by other minor unavoidable errors, or by a combination of two or more of these possible sources of error. The agreement is sufficiently close to give confidence in the measurements as a whole.

Quantities Filtered, Etc.

During the first five weeks of the test 79,360,000 gallons of water were pumped from the lake. Of this quantity 271,000 gallons were filtered without the addition of alum (owing to a break in a steam pipe), 1,400,000 gallons were pumped to the city without passing through the filters, while 77,960,000 gallons passed through the filters. Of this quantity 4,060,000 gallons were used as wash water, leaving 73,629,000 gallons, or an average of 2,104,000 gallons of water per day as the amount of properly filtered water pumped to the city. The quantity of alum used was 20,330 lbs., or 1.83 grains per gallon, reckoned on all the water, including wash water, to which alum was applied. The amount of alum shown by the increase of sulphuric acid in the effluent over the lake water was 2.01 grains per gallon, or 10% more than the quantity shown by the above rates. The average rate of filtration was 1.14 gallons per sq. ft. of filtering area per minute, no deduction being made for the time when filters were out of use for the purpose of being washed, or for the amount of wash water not available for the purpose of supply.

The quantity of alum employed was about 2½ grains per gallon during the first three weeks of the test. This quantity was being used by the O. H. Jewell Filter Co. for the purpose of securing an effluent of the greatest possible purity. As the final payment for the filtration plant depended upon their securing a certain bacterial efficiency for six months, they were unwilling to reduce the quantity of alum before the final acceptance of the plant. It was arranged, however, that the representatives of the city should take no samples for a period of two weeks, and upon that being agreed to by the city, the quantity of alum was, at my request, reduced as nearly as possible to a grain per gallon for the last two weeks of the test, at the expiration of which period the quantity was again increased to about the amount previously used.

Table I. is a tabular statement of the quantities of water pumped, filtered and used for wash water, the amounts not filtered, etc., the quantities of alum used, and the rates of filtration by weeks:

TABLE I.—Water Pumped and Alum Used.
Water Quantities: 1 = 1,000 gallons.

Week ending 6:00 p. m.	Pumped from lake.	Consumption of filt'r'd water.	Treated with alum.	Wash water.	Filtered without alum.	Used without alum. filtrin
June 19	14.700	13,569	14,429	860	271	.....
" 26	15,030	14,160	15,030	870	...	.....
July 3	16,610	14,360	15,210	850	...	1,400
" 10	17,440	16,690	17,440	750	...	.....
" 17	15,580	14,850	15,580	730	...	.....
Total	79,360	73,629	77,689	4,060	271	1,400

Alum Quantities and Rates.

Week ending 6:00 p. m.	Alum used, lbs.	Cost of alum.	Alum, grains, per gall.—Of all water	Alum, grains, per gall.—Calculated from chem. analysis.	Average rate filtration in gallons.—Per sq.ft. per min.	Average rate filtration in gallons.—Per acre daily.
June 19	5,320	$94.54	2.58	2.47	1.06	67,000,000
" 26	5,320	94.54	2.48	2.87	1.10	69,000,000
July 3	4,940	87.78	2.27	2.42	1.11	70,000,000
" 10	2,660	47.27	1.07	1.35	1.28	80,000,000
" 17	2,090	37.14	.94	.97	1.14	72,000,000
Total	20,330	$361.27	1.83	2.01	1.14	71,500,000

Bacterial Results.

In all, 67 samples of lake water as pumped to the filters, and 66 samples of filtered water, were taken for bacterial examination. Two or three sets of samples were taken each day, usually one in the morning and one in the afternoon, and occasionally one in the early evening. No samples were taken during the night. The samples were planted in gelatine by the usual methods, and with a very few exceptions were counted after a five days' growth. A few samples were counted after a four days' growth only.

Mr. Hollis noted that the development of the bacteria in the samples of effluent was somewhat slower than in the lake water, which difference he thought might possibly be due to a retarding influence from the addition of alum. Samples were occasionally taken from the taps in the city, the results from which did not differ materially from those from the outlets from the filters. Samples were also taken on several occasions of the effluents directly after washing, and at intervals during the run.

* The Jewell system of filtration, as in operation at some twenty places, was described in detail in Engineering News for May 21 and 28, 1896.—Ed.

These tests showed substantially the same bacterial efficiency at all periods of the run, and are not here given in detail. The bacterial results secured are shown in the following table, from which the hours of collecting the samples have been omitted for convenience:

TABLE II.—Bacterial Results.

	Week ending June 20.		June 27.		July 3.		July 10.		July 17.	
	Lake.	Effluent.	Lake.	Effluent.	Lake.	Effluent.	Lake.	Effluent.	Lake.	Effluent.
Sunday	...	...	...	...	200	5	202	13	205	13
	...	...	...	...	100	4	...	...	179	27
Monday	95	6	800	14	100	3	125	13	166	26
	135	8	1,150	4	300	7	158	15	80	18
	...	...	...	...	...	...	156	21	...	...
Tuesday	85	...	92	3	*...	*...	108	20	97	18
	67	8	362	10	*...	*...	293	18	250	30
	...	...	...	...	...	...	144	22	...	...
Wednesday	165	7	400	5	500	8	89	11	149	42
	8,392	27	400	5	400	6	207	16	146	27
	...	...	...	...	...	...	155	15	160	20
Thursday	3,485	18	200	5	103	3	175	15	375	33
	620	4	398	5	300	8	159	14	104	21
	...	...	...	...	...	...	99	8	...	...
Friday	163	10	99	4	400	9	79	10	222	35
	975	7	158	5	800	15	260	15	242	28
Saturday	90	3	274	5	500	10	79	10	268	28
	3,020	80	284	6	700	30	82	11	...	...
Average	1,441	16	385	6	367	9	154	14	189	26

* Filters not in operation.

Summary.

Week ending 6 p. m.	Rate filtration, gals. sq. ft. per min.	Alum, grains per gal.	Bacteria in lake water.	Bacteria in effluent.	Bacterial efficiency, per cent.
June 19	1.06	2.58	1,441	16	98.9
" 26	1.10	2.50	385	6	98.4
July 3	1.11	2.27	367	9	97.5
" 10	1.28	1.07	154	14	90.9
" 17	1.14	0.94	189	26	86.3
Average	1.14	1.83	507	14	96.4

During the first week with the largest number of bacteria in the lake water, the bacterial efficiency was 98.9. During the second week with the number of bacteria in the lake water reduced to less than a third, the numbers in the effluent were reduced in nearly the same proportion, and the efficiency remained at 98.4. During the third week, with nearly the same number in the water, there was a slight increase in the effluent and the efficiency fell to 97.5%. For the three weeks the alum used was at the rate of 2.45 grains per gallon and the bacterial efficiency averaged 98.3%.

In the fourth week, when the quantity of alum was reduced to 1.07 grains per gallon, the bacteria in the lake water fell to less than half, while those in the effluent increased considerably so that the bacterial efficiency fell to 90.9%; and in the fifth week, with only 189 bacteria in the lake water, the bacterial efficiency was further reduced to 86.3%, 0.94 of a grain of alum being used. The decrease in bacterial efficiency with the decrease of alum is very marked.

It is much to be regretted that the numbers of bacteria in the lake water during this period were so low, as it is more difficult to secure a high percentage bacterial efficiency when the numbers in the raw water are low than under opposite conditions. On the other hand, the very marked increase in the numbers of bacteria in the effluents following the reduced quantity of alum, notwithstanding the lower numbers in the lake, is unmistakable evidence of reduced bacterial efficiency under these conditions.

The rate of filtration was, for mechanical filtration, extremely low, being much less than that usually recommended as suitable for use with these filters, and only slightly more than half as great as that used by Mr. Edmund B. Weston in experiments made by him with mechanical filters at Providence, R. I., in 1893.*

Microscopical Organisms.

The lake water was examined microscopically on several occasions and was found to contain large numbers of diatoms, algae and other organisms. The effluents were, with a single exception, entirely free from microscopical organisms of all kinds, showing a complete removal of these larger organisms, which are completely removed by almost any filtration.

Examinations of Effluents for Alum.

During the first three weeks of the test, with the larger quantities of alum, samples of effluent were repeatedly examined for alum by the logwood test, and with negative results throughout. For confirmation, samples were sent to Professor Lord, of the Ohio State University, who reports that in the quantity of water submitted, namely one gallon, he was unable to find any alum.

* For an extended abstract of Mr. Weston's report on these experiments, with editorial comments, see Engineering News for April 16, 1896.—Ed.

Chemical Purity Obtained.

Samples of lake water and effluent were sent to Professor Lord, who anlyzed them with the following results (in parts per 100,000.—Ed.):

	Lake water.	Effluent.
Color	0.05	None.
Turbidity	Distinct.	None.
Sediment	Slight.	None.
Odor	Slight, earthy.	None.
Free ammonia	0.0015	0.0014
Albuminoid ammonia	0.0146	0.0076
Nitrogen as nitrates	0.0170	0.017
Nitrogen as nitrites	0.0003	Trace.
Total solids	27.3000	23.0000
Volatile solids	12.0000	8.0000
Chlorine	0.5800	0.6000
Oxygen consmued	0.2300	0.1300
Temporary hardness	9.4000	7.4000
Permanent hardness	1.6000	3.0000
Total hardness	11.0000	10.4000

These analyses show the removal of nearly half of the organic matters and all of the color, turbidity, sediment and odor, and the effluent is entirely satisfactory from a chemical standpoint.

Summary.

These tests show the removal of about 98% of the bacteria of the lake water when filtered at the rate of 1.1 gallons per sq. ft. per minute and with the use of 2.5 grains of alum per gallon, and the removal of about 90% of the bacteria with a rate of filtration of 1.2 gallons per sq. ft. per minute and a grain of alum per gallon. They also show that the alum was completely decomposed and did not appear in the effluent.

Dr. Probst, in submitting Mr. Hazen's report to the Board of Health, made some comments on the above figures, and concluded as follows:

I have to recommend, therefore, that the change in the water supply of Lorain be approved, subject to the conditions that the maximum rate of filtration be 100,000,000 gallons per acre daily, and that not less than 2.5 grains of alum per gallon be used.

While recommending approval, I would suggest that the attention of the authorities at Lorain be called to the fact that their filters during other seasons of the year may be subjected to a severer trial than the one here reported; that so long as sewage is turned into the Black River the consumers of the lake water have to depend upon the honest, intelligent operation of these filters to protect them against disease; that the results of filtration can be known only by daily bacteriological examinations, for which provisions should be made. I would add further that it be suggested that the best interests of the city demand that an effort be made to free Black River from sewage pollution; and that it be pointed out that, if this is not done, it may be found advisable that the water works intake be extended to a point where the danger from pollution is not so great.

The report of Dr. Probst was approved by the State Board of Health.

RULES FOR THE USE OF PRIVATE FIRE SUPPLIES PROVIDENCE WATER-WORKS.*

Applications for private fire supplies must be accompanied by a full detailed plan, showing all connections contemplated with other fire supplies, tanks, and sewers, which shall be approved by the city engineer before action will be taken thereon.

No changes, additions or connections will be allowed except upon plans filed and approved in the same manner as with the original application for said supplies.

All work in connection with private fire supplies shall be done by a licensed plumber and under proper inspection, and all gates, valves, fire-plugs, and hydrants connected with such supply shall be sealed by the inspector when deemed necessary.

For the purpose of covering the expense of a proper inspection of the complicated systems of private fire connections now demanded, the following yearly rates will be charged, when Pawtuxet water is exclusively used for general purposes, viz:

For one (1) supply	$5.00
For two (2) supplies, connected, but without auxiliary tank	10.00
Either one (1) or two (2) supplies connected to tank	15.00

When other water than that furnished by the city is used for general purposes, special contracts or larger assessments will be made.

Private fire supplies and the fire apparatus connected with the same, may be tested by the parties owning the same, or by insurance inspectors, under the following conditions:

(1) Notice to be given at the office of the Commissioner of Public Works that such test is desired, when date and hour will be agreed upon for said test.

(2) All tests to be made in the presence of the inspector assigned by the Commissioner, whose sole duty shall be to remove and replace the seals used on the fire apparatus and note the time required in making the test.

(3) The rates for testing are as follows:

One hour or less, $3; for all time in excess of one (1) hour, $1 for each hour or fraction thereof.

(4) Water shall not be used from any private fire supply, nor seals broken or removed, except in case of fire, written notice of which is to be given at the office of the Commissioner within 24 hours after its occurrence.

(5) Not more than two private fire connections from the city water mains will be allowed to any building or premises, except under exceptional circumstances, to be determined by the Commissioner. The connections may be made from one or more streets if the building or premises fronts upon the same. No pipes, however, will be allowed to be laid across a street.

Not more than two private fire connections from the city water mains will be allowed to be connected together under any circumstances in any building or premises.

When two private fire connections are connected together, a suitable check-valve must be placed upon each.

In conformity with the order of the Board of Health, no private fire system which is in any manner connected to the city water mains shall have any other supply of water. No valves of any description will be allowed as "shut-offs" to any other supply, as there must not be a possibility of any other supply of water to such pipes.

When a tank is connected to a private fire system which is connected with the city water mains, it shall be subject to the following conditions: The only water that will be allowed to be supplied to the tank will be the water furnished by the city. Said water shall be measured by a meter. The supply pipe leading to the tank shall be entirely independent of the fire system proper. It can be directly connected to the city water mains, or to a regular service pipe which supplies city water to the premises where the tank is located.

The outlet end of the supply pipe of a gravity tank shall be placed at least 6 ins. above the maximum water line of the tank, and the supply pipe of a pressure tank shall be so arranged as to prevent the water in the tank from flowing back into the city water mains. Each tank shall have a suitable check-valve upon the pipe leading from it to the distribution pipes of the fire system, for the purpose of preventing water from flowing into the tank from the city water mains.

A gravity tank shall be roofed over and constructed to prevent, rain, snow, dust, or any other objectionable matter from getting into it. Each tank shall have a manhole and permanent ladders arranged for convenient access to its interior, and shall have an outlet in its bottom, so that it can be emptied entirely independent of the pipes of the fire system. The interior of each tank shall be thoroughly scoured out at least once in twelve months.

All "drips" of fire systems, which are intended to empty into a sewer, shall first discharge into an open tank, the outlet pipe of which shall be deeply trapped and connected with the sewer in the usual manner.

(6) For each and every violation of the above, in whole or in part, the offending party, at the discretion of the Commissioner, will be subject to a fine of not less than $5 nor more than $50, or be subjected to having the supply shut off.

Owners or agents of property protected by private fire supplies shall cause copies of rules one to six to be kept posted conspicuously in their office, engine-room, and upon each floor of any building where fire-plugs are located that can be used by any employé; and no plea of ignorance will be entertained by the Commissioner.

* Reprinted from the official rules issued by Mr. Robt. E. Smith, Commissioner of Public Works, Sept. 14, 1897.

AMERICAN CONTRACTORS are reported to have built and equipped or to have now under contract, the following electric railway lines in Great Britain and Ireland:

City.	Miles.	No. of Motors.	HP. of Plant.
Bristol	10	36	800
Cork	11	20	400
Coventry	3½	10	240
Dublin	15	60	600
Dublin	5	15	300
Guernsey	3	13	150
Isle of Man	4	16	200
Staffordshire	8	20	600
Brighton	3	10	240
Central London	13	52	1,000

ADDITIONAL COAST DEFENSE FORTIFICATIONS are urged in the report of Gen. Nelson A. Miles, Major-General commanding the Army, which has just been submitted to the Secretary of War. Gen. Miles states that approximately $26,000,000 have thus far been appropriated by the government for coast defense, which is about one-third of the sum required to put the country in safe condition for defense. The principal additional appropriations for fortifications, which Gen. Miles recommended, are in amount and location as follows: Boston Harbor, $1,347,000; Narragansett Bay, $833,000; defenses of Long Island Sound, $1,070,000; eastern entrance New York, $489,000; southern entrance New York, $1,419,000; approaches to Philadelphia, $141,000; approaches to Baltimore, $499,000; approaches to Washington, D. C., $694,000; Hampton Roads, $463,000; San Francisco, Cal., $1,336,000; Columbia River, $695,000; Puget Sound, $1,140,000. An increase in the army of at least two additional regiments of artillery is also urged.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The serious accident on the New York Central & Hudson River R. R. this week, in which 20 persons lost their lives, has attracted an unusual amount of public interest, because of its unusual cause. That a stretch of apparently solid embankment on one of the very best railways of the world, subjected, it is to be supposed, to as careful inspection as can possibly be given, should sink without warning and leave a gulf into which a fast express train plunges, is to say the least disquieting. Railways in a limestone region and in some mining regions have occasionally had their tracks sink into underground cavities, but no such explanation of the present disaster can be accepted as probable.

The ideas which have been put forth to the effect that a derailment or breakage of the engine axle caused the embankment to give way seem to deserve no more credence. Even if this were true, the case would be no better for the embankment, for everyone knows that stable embankments are not removed bodily by collisions or derailments in any such manner.

The simple fact that the embankment under the south bound track has disappeared, proves that this embankment was unstable and unsafe; and it only remains to be determined what was the cause of its weakness and failure. It may be said at once that this question cannot be positively answered until the investigation to be made by the State Railroad Commission is completed; and it is not likely to be settled in all points then unless an examination is made of the rock or earth that underlies the roadbed at the point where the disaster occurred.

At the present time, the statement of Roadmaster Otis, published elsewhere in this issue, appears to shed more light on the real cause of the disaster than anything else which has been made public, and we presume it represents as much as is really known at the present time by the officers of the railroad company.

Reviewing now the facts of the case, they appear to be as follows: The north bound track, which was the first one built and which did not slide into the water, was made by filling in broken rock, excavated from the cuttings near by. The south bound track was added at a later date by dumping earth and gravel filling on the river side. This filling, of course, rested on the steep outer slope of the older embankment, and it is altogether probable that the rock ledges directly beneath it also slope steeply toward the river. The rough rubble wall which was built on the outer side of this embankment, was in all probability not designed or expected to act as a retaining wall but merely to protect the embankment from the wash of the waves and tides. The stability of the wall seems to have been a matter of no concern to the railway officers. If Mr. Otis is correctly reported, when the level of the embankment was raised a short time ago, the old wall was found to have bulged outwards. But, says Mr. Otis: "the bulging was of no consequence whatever;" and the new masonry was laid on top of the old wall, increasing its height, and its instability without a word of question. It does not appear to have occurred to anyone connected with the work in any capacity, that this wall actually held in place the embankment beneath the south bound track; but we are forced to believe that the fatal accident of last Sunday morning proves this to have been the case.

Earth embankments of such materials as the one in question seldom or never fail suddenly without giving warning of their unstable condition. The outer part of the bank slides off first, or, in very soft material, the whole bank settles. It seems a wholly untenable hypothesis that this great mass of earth should have been in so unstable a condition as to all at once slide into the river without giving long ago some warning of its condition to the careful inspectors who continually watch this roadway.

When, however, any such embankment is supported by a retaining wall, failure of that structure may at any time cause failure of the earth embankment. That this embankment had been exerting pressure against the wall at its foot is shown by Mr. Otis' statement that the wall had bulged. Walls do not bulge unless there is pressure behind them. The failure of the wall itself is not difficult to account for. It was in all probability never designed to act as a retaining wall; the weight of the earth mass behind it had been increased by raising the level of the tracks, and even the strains due to heavier and faster trains may have been transmitted to it. Remembering now the statement of Mr. Otis that this wall had been recently increased in height, and also the fact that unusually high tides had submerged it to a greater depth than usual and had raised the water level in the filling behind it, and it is not hard to explain the final overturn of the wall. When the support of the wall was removed, the embankment, resting as we have explained, on a more or less sloping foundation, slid into the river either under the weight of the train or perhaps during the interval after the passage of the last preceding train.

If the assumptions on which the above explanation of the accident is founded are proved correct, the lesson of this sad accident will be so plain that it hardly needs to be pointed out. To support an earth embankment by a retaining wall is unsafe, unless the wall is designed to withstand the pressure that may come upon it. Calling a wall by some other name does not prevent it from acting as a retaining wall if earth is filled in behind it. If any wall is built at the foot of an embankment, build it strong enough for its work, or else do not build it at all.

The possibility of determining the character and intensity of the strains in metals by measuring the heat gained or lost when the load is applied, is discussed by Mr. C. A. P. Turner in an interesting paper read before the Engineers' Society of Western Pennsylvania, on Oct. 19, and published in the "Proceedings" of that society for September. It is a familiar fact that all substances, as far as is known, either gain or lose heat when subjected to a tensile strain or are stretched, the rule being that those substances grow cooler upon being stretched, which expand by heat, and vice versa. With iron or steel, therefore, heating denotes the compression and cooling denotes the tension of the metal. Briefly stated, Mr. Turner has attempted by actual experiment to determine whether this phenomenon might not be turned to practical use in testing steel and iron for structural work. In these experiments bars of soft and medium steel of various kinds, cast-iron bars, and short columns of steel were subjected to tension and compression and the increase or decrease of temperature measured, and, finally, a plate girder 2½ ft. deep and 10 ft. long was tested by flexure to bring out, if possible, the tensile and compressive strains induced by bending and shear at different points in the web and chords.

For the exceedingly delicate measurements of temperature required to make these tests of value, Mr. Turner used the thermo-electric current generated by a Melloni antimony-bismuth thermopile and recorded by a Thomson astatic reflecting galvanometer. With the instruments used he estimated that a variation of 1-3,000 degree Centigrade could be determined. The method of operation was simply to attach the thermopile properly to the test bar and to lead wires from it to the galvanometer, the deflection of whose needle recorded the intensity and the changes in direction of the electric current caused by the changes in temperature. Without going any further into the methods of making the tests the conclusions which Mr. Turner draws from the results obtained may be summarized as follows:

(1) That stress can be quite accurately measured by the change in thermal condition of the piece, when the load is applied, if the stress does not exceed about five-eighths of the commercial elastic limit.

(2) That difference in the intensity of stresses of the same kind, though slight, occurring at two different points, can easily be detected by a modification of the same apparatus.

(3) For medium steel there appears to be a thermal limit, below which the test piece grows slightly and regularly cooler as the tensile stress is increased, and beyond which for a considerable space there is little change, until the commercial elastic limit (the drop of the beam) is reached, when heat is generated so rapidly that the curve is almost normal to the axis of abcissas.

It is also pointed out in the paper that for compression there is likewise a thermal limit below which the piece grows regularly warmer as the stress is increased, until the limit is reached when there is a sudden rapid increase in the temperature.

The low limit of strain at which the thermal condition of the metal apparently ceases to be an accurate index of the intensity of the strain seems to take it at once out of the field as a practical commercial test for structural material. If this were not the case, however, it seems to us quite likely that the delicacy of the test alone would relegate it to the experimental laboratory. It is no easy matter to calibrate a galvanometer, and where such exceedingly minute changes of temperature as thousandths of a degree are concerned the entire isolation of the thermopile from variations of heat and cold which are extraneous to the test is obviously a matter of great difficulty, and one which can be overcome only where the conditions can be made very perfect, as in a well equipped laboratory.

A possible field of usefulness which we think may be open to the thermo-electrical test of metals is in carrying on such experiments as were made by Mr. Turner on the full-size plate girder mentioned above. In built-up members of various sorts where the necessary imperfections in workmanship and design are likely to introduce ambiguous strains, which cannot be determined by theory or by ordinary physical tests, the determination of the character of the strains by recording the thermal conditions of the metal under load, if it can be made reliable and accurate, would be a very valuable aid to engineers in designing such members. For these reasons considerable interest is attached to the plate girder tests described by Mr. Turner's paper.

As already stated, this girder was 2½ ft. deep and 10 ft. long. It was constructed in the usual manner of riveted girders, with riveted angle chords and ends, and with the web reinforced with vertical angle stiffeners spaced the depth of the girder, or 2½ ft. apart. The first test made on this girder was a physical test of a very novel character. Alternate panels of the girder web were buckled ⅝-in. to form a flat pyramid, the edges of which formed the diagonals of the panel. Evidently, if the tensile and compressive web stresses are distributed as in a beam of constant cross section, that is equal to each other and acting at

angles of 45° with the axis of the beam, then when the bending load is applied the lateral components of the tensile and compressive strains will balance or neutralize each other, and there will be no lateral motion or spring to the pyramid or buckle. If, however, the tensile stress is the greater the buckle will spring in as the load is applied and go back when the load is removed. In the actual test the inward spring of the buckle was ⅛-in. under a bending load of 28 tons, at the center of the girder.

The girder under load was next tested by the thermo-electrical apparatus. Remembering that cooling denotes tension and heating denotes compression, we will let the author tell the results in his own words:

> The first series of measurements were made on the neutral axis of the web at points near the stiffeners and in the centers of the panels. Marked heating effect was obtained in the plate near all stiffeners, and cooling effect in the center of all panels. These readings were tested by reversal of the connection, giving equal reverse deflections for the same load. The stiffeners were next examined, and all were found to be under compression, and one, owing to the fact that the girder was slightly warped, was found to be under compression and bending. In the outstanding leg on one side there was a small amount of tension, while on the other side we obtained about three times the deflection, indicating compression. With regard to the magnitude of the diagonal tensile stress in the web, evidently the compressive stress acting normal to the tensile stress would produce a heating effect that would partially offset the cooling effect of the tension, so that the galvanometer reading is only an indication of the difference in the intensities of these stresses. Were there no defiction at all on the neutral axis, we would conclude the tensile and compressive stresses were equal, as in a beam of constant section. Application of the thermopile to the neutral axis of our I beam lever, when under stress, gave no deflection, as should be the case under the common theory. A series of readings were taken to determine the relative magnitude of stress in the top and bottom flanges. The measurements were taken at points vertically over each other in the center of the panels. The result shows stress in bottom flange, center panel, two-thirds of that in the top, and in the end panel, half as much as in the top flange.

The conclusions which Mr. Turner thinks are to be drawn from these results is that the practice of using vertical stiffeners is correct from the standpoint of both efficiency and economy, but that the practice of proportioning flanges and spacing rivets is somewhat in error.

THE BACTERIAL TEST OF MECHANICAL FILTERS AT LORAIN, O., AND RESULTING SUGGESTIONS.

Some valuable information regarding the bacterial efficiency of mechanical filtration is presented in the report, which is given in another column, on a five-week test of a 3,000,000-gallon water filter plant built for the city of Lorain, O. This report is doubly welcome, because of the good bacterial results shown and because of the scantiness of the data on the subject. The only important bacterial tests of mechanical filters heretofore made public were those conducted at Providence, R. I., in 1893-4, by Mr. Edmund B. Weston, M. Am. Soc. C. E.* While these experiments were carried out with extreme care, and extended over nearly a year, Mr. Weston's conclusions were based on two short runs aggregating 33 days, or two days less than the Lorain test. Moreover, Mr. Weston used only a small experimental filter, 30 ins. in diameter, while at Lorain there were six filters, in practical, every day service, having a combined available filtering surface of 1,356 sq. ft.

It is true that during the test the Lorain plant was still in the hands of its friends, the contractors, they having agreed to operate it six months before its acceptance by the city, and having guaranteed to remove 97 per cent. of the bacteria in the applied water, this guarantee not to apply when the number of bacteria in the effluent falls to 200 per cu. cm. But there is no indication in the report that the city cannot secure as good results as were shown by the test. The test showed that so long as the filter plant was operated with the amount of alum which the contractors deemed appropriate, the guaranteed efficiency of 97 per cent. average bacterial reduction was exceeded, this excess for the first three weeks of the test being 1.3 per cent. The average amount of alum used during this period was 2.45 grains per gallon of applied water, ranging, according to numerous tests, from 3.9 to 2.1 grains per gallon. For experimental purposes the amount of alum was decreased during the fourth week of the test to an average of 1.07, and during the fifth week to 0.94 grains per gallon; the percentage of bacteria removed thereupon fell to 90.9, and 86.3, respectively. The number of bacteria in the applied water was very low at this time, being only 154 per cu. cm. for the fourth, and 189 for the fifth week, against an average of 731 for the first three weeks and of 507 for the whole period. This partly accounts for the low percentage of removal, but only in part, since the actual number of bacteria remaining in the effluent was 14 and 26 for the fourth and fifth weeks, respectively, against 16 for the first, 6 for the second, and 9 for the third week.

The water consumer cares, or should care, far more for the actual number of bacteria than for the percentage of removal. From this standpoint, the results for the whole period are highly satisfactory, especially when we remember that the bacteria in the effluent during the last two weeks probably might have been reduced practically to zero, if desired, with a more liberal use of alum.

For the worst week there was an average of only 26 bacteria per cu. cm., and for the five weeks only 14. Of 66 samples of filtered water examined in the five weeks, only four contained over 30 bacteria per cu. cm., the instances being 80 with 3,020 in the applied water the first week of the test, and 42, 35 and 33, with 149, 222 and 375 bacteria, respectively, in the applied water, during the last week. In the first three weeks 16 of 35 samples of effluent contained five or less bacteria per cu. cm. Certainly these are highly gratifying results.

The Ohio State Board of Health, for whom these tests were made, conditions its approval of the plant upon the use of not less than 2½ grains of alum per gallon of water filtered, and a maximum rate of filtration not to exceed 100,000,000 gallons per acre per day. The results shown by the test were obtained with comparatively low rates of filtration, but about the above quantity of alum was used when the highest average bacterial efficiency was reached. Now 2½ grains of alum per gallon, with alum at 1¾ cts. per lb., the approximate cost at Lorain, means an expense for alum alone of about $6.25 per 1,000,000 gallons passing the filters. Some of this water must be used for washing, the amount used for this purpose during the test being 5½ per cent. of the quantity of filtered water available for consumers. Allowing only 4 per cent. increase in the amount of available water on account of the waste for washing, we find that the alum for wash water alone costs about 25 cts. per 1,000,000 gallons of available water, increasing the cost of alum to $6.50 per 1,000,000 gallons of water delivered to consumers. Using one grain per gallon, the approximate rate during the last two weeks of the test, the cost of alum would be reduced to 40 per cent. of the above, or $2.60 per 1,000,000 gallons. Would it have been worth while during the last two weeks of the Lorain test to have increased the cost of alum used by 150 per cent. for the sake of making any further reduction in the number of bacteria? We have already seen that during these last two weeks the number of bacteria exceeded 30 per cu. cm. but three times, and averaged only 20. Assuming that 2½ grains of alum per gallon would have removed all these, would the fact that the water was sterile have been worth $3.90 per 1,000,000 gallons? As a practical matter, in the light of our present knowledge, it would not. Doubtless some bacteria would have remained, even had as much as 2½ grains been used. Perhaps, however, it might have been worth while to use a little more than one grain per gallon.

The above suggests two points for consideration: (1) The proper basis of judging the bacterial results of filtration, and (2) the value of frequent bacterial analyses. Regarding the first point, let us examine some of the figures obtained in the Lorain tests. The greatest number of bacteria in any sample of unfiltered water was 8,392 per cu. cm., of which only 27 appeared in the filtrate, showing a removal of 99.7 per cent. On the same day another set of samples showed 165 and 7 bacteria, in the crude and filtered water, respectively, a removal of 95.2 per cent. The highest number of bacteria appearing in the effluent during the whole test was 80, out of 3,020 in the applied water, a removal of 97.4 per cent. On the very same day another set of samples showed 90 bacteria in the unfiltered, and three in the filtered water, yet the removal with but three bacteria in the effluent was only 96.6, or 0.8 per cent. less than in the case of the effluent containing 80 bacteria. These examples are taken from the results obtained the first week, when the maximum amount of alum was being used.

Within certain limits percentages are very useful in comparing results, but outside those limits they may easily become very misleading. It is conceivable that in the future the water at Lorain may contain an average of 10,000 bacteria per cu. cm. for some days or weeks. A 97 per cent. removal would still leave 300 bacteria per cu. cm., or more than 20 times the average for this five-week test. The ideal to be striven for is a complete removal, but, like other ideals, this one cannot always be fully realized, at least within practicable limits of manipulation and expense. If we could have complete removal 100 per cent. would be the standard, and that would end this discussion. As we cannot, and as even very high percentages, when large numbers of bacteria are present in the water to be filtered, leave us with high absolute numbers in our effluent, we find it advisable to set some maximum limit in actual numbers. But absolute dependence should not be placed on this number limit, for with few bacteria in the applied water a reduction in the standard might be effected while the filter was in poor condition. A sudden increase of bacteria might occur and the number limit be far exceeded before the defects in the filter were remedied. Or again, the water might, at periods, be so high in suspended matter and bacteria as to make it practically impossible to reduce the bacteria to the number standard, although a percentage standard would be far exceeded. Conditions can be imagined when a community would be thankful to be rid of 75 per cent. of the danger lurking in their water supply, although absolute safety is always far preferable. With both standards, averages for weekly or monthly periods cover up exceptional cases of high bacteria, which may indicate something wrong with the filter. The longer the period for which the average is taken the greater the necessity for considering carefully the individual analyses, for occasional poor results will show where only a short series is averaged, but will tend to be lost as the length of the series increases.

The conclusion to be drawn from the above is that the bacterial results of filtration can be studied to the best advantage by considering both the percentage of bacteria removed and the actual number of germs remaining in the effluent; or, what is about the same thing, that either a sliding scale of percentages or of absolute numbers should be employed, the standard rising in either case with an increase in the number of bacteria in the applied water, or falling under the reverse condition. This would ensure good water at all times, without over-refinement, on the one hand, or the danger, on the other, that in avoiding over-refinement with bacterial results when the natural water is unusually good, the filter may be allowed to get out of order and endanger the supply when the water changes for the worse.

The hygienic importance of frequent bacterial examinations is evident from the above. Their financial value must also be evident, at least after a moment's reflection. To illustrate the financial aspect by a concrete example, let us refer to Tables I. and II. Under the hard-and-fast rule laid down by the Ohio State Board of Health, not less than 2½ grains of alum would always be used at Lorain. Yet during the last two weeks of the test the number of bacteria in the effluent never exceeded 42, and averaged only 20 per cu. cm., although the amount of alum used averaged only one grain per gallon. There is no indication in the report that the general condition of the plant suffered because of this reduction in alum, and to increase the amount of the coagulant as soon as the water begins to grow worse is always a matter of a few moments.

Let us next compare the last week of the test with the first, remembering that we are, for the moment, considering the financial side of the prob-

* See Engineering News, April 16, 1896.

lem. During the first week the amount of alum used was 2.58 grains per gallon, against 0.94 grains, or a little over one-third as much in the last week. The relative amounts of water filtered were 15,580,000 gallons in the last week, and 14,429,000 in the first week of the test, corresponding to rates of 72,000,000 and 67,000,000 gallons per acre per day, respectively, an increase of 7 per cent. in the last week. The total cost of alum for the last week, had no more water been filtered than during the first, would have almost exactly $60 less on account of the smaller amount of alum used per gallon of water.

Without some accurate means of determining the bacterial contents of the applied and filtered water day by day, it is not safe to vary much from an alum rate sufficiently high for the water in its worst condition. In some cases this will result in a material and unnecessary increase in the cost of filtration, for alum alone, which would pay for frequent bacterial analyses.

Returning to the hygienic aspects of the case we have to remember that financial considerations are far too often placed above all others, consciously or unconsciously, so if an attempt is made to establish an arbitrary alum rate, the latter is likely to be far too low. This may cause dangerously poor bacterial results without the fact being known until shown, perhaps, by a sudden rise in the typhoid death rate, too late to prevent an epidemic of this unnecessary water-borne disease.

If an attempt be made to vary the alum to suit different conditions of the water, the conditions being judged by physical appearances rather than analyses, the rate again is almost sure to be too low, and the alum to be omitted entirely at times of especially clear water. Or if a strong desire to protect the health of the people exists, the alum rate may be too high, and waste will occur. With high alum rates, and frequently uncertain rates, more alum may be added than can be decomposed by the water, unless it is high in certain calcium compounds. The consequence then will be that some of the alum will pass the filters and be delivered to the consumers, a highly undesirable occurrence. At Lorain, although the alum rate went to nearly four grains per gallon on at least one occasion, no trace of alum was found in the filtrate, but with a higher rate, or on some other water supply, the alum might have appeared. We find, then, that both health and economy demand frequent bacterial tests in connection with mechanical filter plants. Such tests also give information as to the proper manner of manipulating filters in other respects, which we cannot now consider. Other phases of water purification might demand chemical analyses in addition, but this, also, cannot now be discussed.

One other line of thought suggested by the report demands a few words before concluding this discussion. In comparing the relative cost of mechanical and slow sand filtration the amount of alum required in the former process has been assumed, in several instances, at one grain per gallon, and this has been the amount quite generally given by the manufacturers as the maximum average. If 2½ grains per gallon are necessary at Lorain, as advised by the Ohio State Board of Health, the cost of alum alone, over $6 per 1,000,000 gallons, is about equal to the total figures given in several estimates of the cost of slow sand filtration, including interest and depreciation on the plant. The contractors were operating the plant with about this average rate of alum before they were asked to reduce it, experimentally, but of course they were determined to maintain the contract standard of bacterial efficiency at any cost. Possibly the cost of a high bacterial efficiency with slow sand filtration at Lorain would also be above the average. The process might have to be supplemented by sedimentation, thus increasing the expense, although the report contains no data from which such a conclusion could be drawn, unless it be the frequent washings given the filter. This phase of the report suggests the need of more information regarding the quantity of alum required for various classes of water in order to obtain high bacterial results. Nearly all the mechanical filter plants yet built were put in to clarify water. Little has yet been determined, or at least made public, regarding the amount of alum required in the bacterial purification of water, as observed in actual practice. Mr. Weston, in the Providence experiments mentioned above, reached the conclusion that an average as low as 0.6 grain per gallon was sufficient for the Pawtuxet River water, and in his recent paper on the "Filtration of Water," abstracted in our issue of Oct. 7, he stated that he "considered one grain of sulphate of alumina per gallon" to be "a fair general average of the quantity that would be required for a large number of differently constituted waters." If Mr. Weston is right, the water at Lorain must be outside this class, or the standard fixed in the contract must be too high, or the contractors must be striving to make a good bacterial record without regard to cost, or, if none of these assumptions are true, an unnecessary and wasteful amount of alum was used the first three weeks of the test, and is now recommended for continued use by the State Board of Health. Light on this point is desirable.

While awaiting it, it is pleasing to know that mechanical filtration can achieve such excellent bacterial results as at Lorain, even if the cost is high. Some things are worth paying well for, and pure water is one of them. At the same time, we hope the events will prove either that pure water can be secured at Lorain at a less expenditure for alum than some $6 per 1,000,000 gallons, or that this and other cities with as bad or worse water to be filtered can effect the desired purification at a considerable reduction in total cost by the use of slow sand filtration, even if necessary to supplement it by sedimentation.

LETTERS TO THE EDITOR.

The Railway Bridge Over the St. Lawrence at Quebec.

Sir: I have to thank you most cordially for your valuable article on the proposed bridge, in your issue of Oct. 14, but have to correct one statement therein. Mr. Shaw prepared the design for the bridge, but is not officially connected with the bridge company, Mr. E. A. Hoare, of Quebec, being the engineer for the company, and no definite plans have yet been adopted. Yours truly,

Ulric Barthe,
Secy., Quebec Railway Bridge Co.

Quebec, Can., Oct. 21, 1897.

A Good Day's Journey by a Steam Motor Carriage.

Sir: It may be of interest to your readers to know of a recent trip made by a motor carriage over the common country roads of New England, from Boston to Claremont, N. H. The distance is about 125 miles, and the run was made in a day, the actual time on the road being a little less than nine hours.

The carriage was a one-seated buggy, and weighed, complete, with fuel and water, about 800 lbs. The motor and boiler weighed about 80 lbs., the power being steam and the fuel naphtha, while the pressure carried was 100 lbs., giving 4½ HP.

The carriage was made by the Whitney Motor Carriage Co., of Boston, and the writer understands that while this carriage is one of the first built the company has several under construction, from which even better results are expected. W. A. W.

Sunapee, N. H., Oct. 20, 1897.

Credit for the Design of the Harlem Ship Canal Bridge.

Sir: On the inset of the issue of Engineering News of Oct. 7 I observe that Mr. A. P. Boller is named as the "chief engineer" of the Harlem Ship Canal Bridge. You have advised me that the title of the inset was completed by a member of the staff of your journal, but the paper by Mr. Boller on "The Aesthetics of Bridge Design," etc., in the same issue, is apparently written with much care to convey the impression that he (Mr. Boller) was the responsible engineer of the work. As I was appointed consulting engineer to the Department of Public Works in the latter part of October, 1892, for the construction of the Harlem Ship Canal Bridge, Mr. Boller had no official or responsible connection whatever with that work. While I was absent in Cambridge, Mass., in the winter and early spring of 1892-93, he developed partial masonry and foundation plans, subject to my approval, and which I was obliged to change in several material particulars before the work was done. After my permanent return to New York, in May, 1893, practically before work was begun, he was relieved of further attention to the work, except as to railing and lamps. The records of the Department of Public Works and of the Board of Estimate and Apportionment, the stress and estimate sheets in my possession, my official signature on the contract and working drawings, and my correspondence with the contractors, could, very pertinently, be cited in connection with the matter, but having made the preceding bare statement of the facts, I shall give it no further attention.

Very truly yours, Wm. H. Burr.

151 West 74th St., New York, Oct. 21, 1897.

(We submitted a proof of the above letter to Mr. Boller with an invitation to make reply in the same issue, in accordance with our rule when letters are sent to us for publication criticising any person or firm. His reply is as follows.—Ed.)

Sir: Thanks for your proof slip of Professor Burr's criticism of my paper on "Aesthetics of Bridge Architecture" in Engineering News of Oct. 7. Professor Burr takes offense at the inferences drawn from the account of the Harlem Ship Canal Bridge, complaining that his proper relation to the work was not set forth. In reply I would say that Professor Burr is perfectly correct in saying he was officially appointed consulting engineer of this work by the Commissioner of Public Works. I think I intimated as much in a foot-note to the article. The facts are that this work was originally intrusted to me, the general plan made and adopted by the Commissioner, but owing to personal friction between myself and a member of the Board of Estimate (which Board had to make final approvals before expending money) my appointment by the Commissioner could not be viséd. At my request Professor Burr, whom I had contemplated taking in as a partner in my business, was appointed in my place, although unknown to the Commissioner, either personally or as having ever designed and carried out any work of this character. The work was all done in my office (Professor Burr was a professor at Cambridge) and I allowed a generous proportion of the fee. Our arrangement in case of a partnership had been 4-10 as Burr's proportion and 6-10 my proportion; but he pleaded for a little more on this work, in view of his name officially appearing as its author, and I acceded to a division of 45-100 and 55-100 respectively. Keeping the "controlling interest," as they say in corporations. That Professor Burr is ignoring my connection with this work in his writings on the subject, should prove disloyal to me, hurts him a great deal more than it does me, and he is welcome to all that he can make out of the matter.

I think with the above facts in mind, and a contemplation of the executed work, the profession will not be at a loss "to give credit to whom credit is due."

Yours truly, Alf. P. Boller.

27 Pine St., New York city, Oct. 25, 1897.

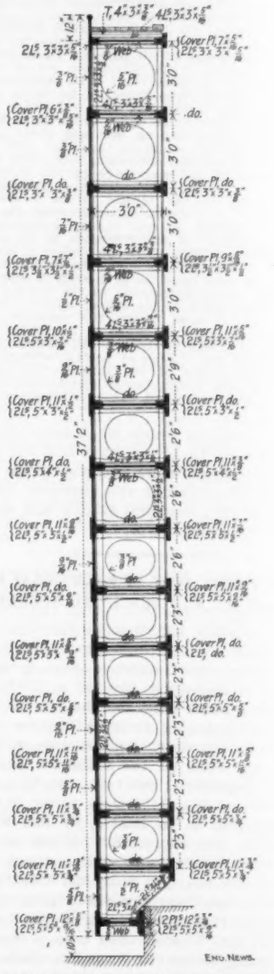


Fig. 8.—Vertical Section of Lower Guard Gate

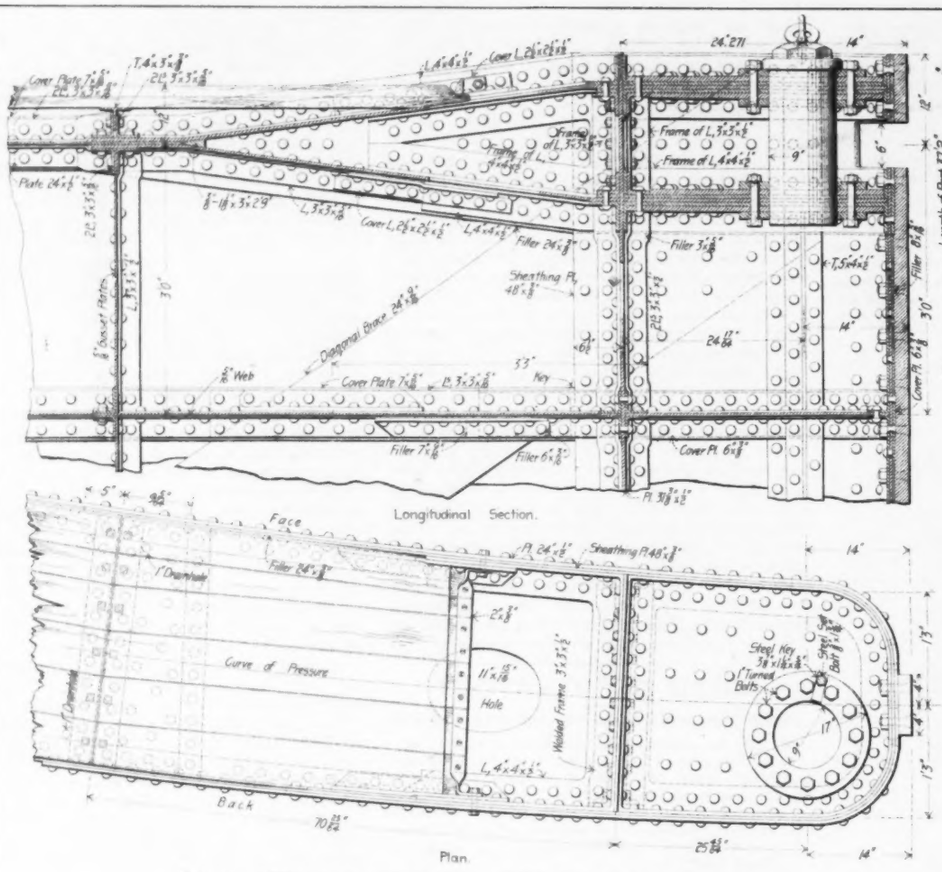
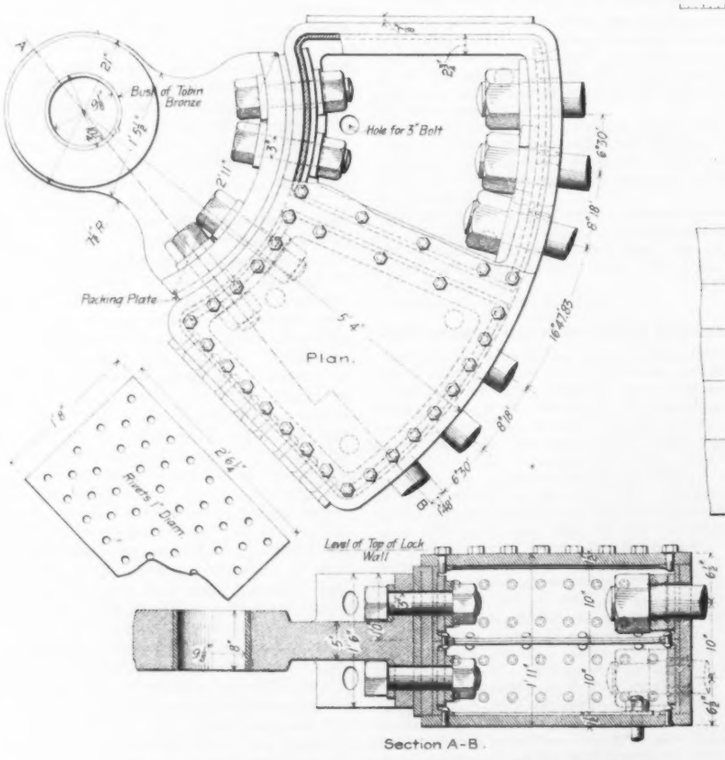


FIG. 12. DETAILS OF QUOIN POST, UPPER END OF LOWER GUARD.

FIG. 11. DETAILS AT OUTER END OF GATE NEAR BOTTOM.



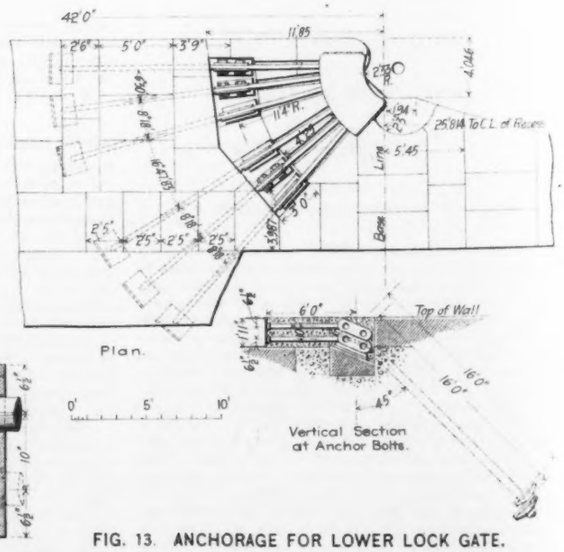


FIG. 14. DETAILS OF ANCHORAGE BOX, LOWER LOCK GATE.

FIG. 13. ANCHORAGE FOR LOWER LOCK GATE.

THE LOCK ON THE CASCADES CANAL, COLUMBIA RIVER, OREGON.

Engineers, Major Thomas H. Handbury and Capt. Edward Burr, Corps of Engineers, U. S. A.

Contractors, J. G. & I. N. Day, Portland, Ore., and the Maryland Steel Co., Sparrow's Point, Md.

CHAS. HART & BONS, LITH., 32 VESEY ST., N. Y.

DETAILS OF GATES FOR THE CASCADES CANAL LOCK.

(With full-page plate.)

In our last issue we described at length the lock on the Cascades Canal on the Columbia River, and the great steel gates of the lock, which are believed to be the largest canal lock gates ever built. We now supplement the general illustrations of the lock and its gates, which were given in our last issue, with drawings showing the details of construction of these great gates. The design of these gates and their connection to the masonry may seem a simple problem; but the magnitude of the masses to be moved, the huge scale on which the work had to be carried out and the enormous strains due to the weight of the structure, and to water pressures and wind pressures, made the problem one requiring no small ability to solve correctly.

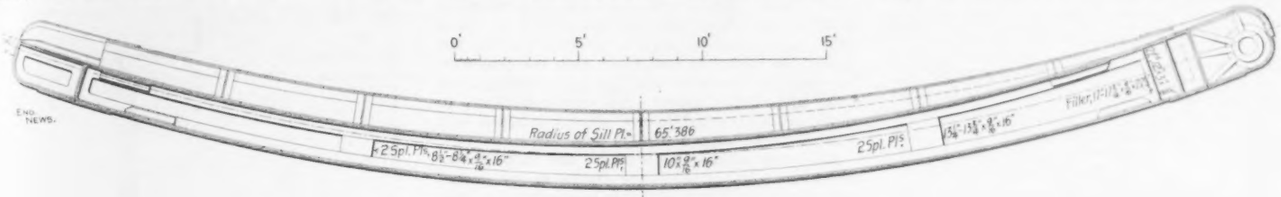


FIG. 9.—PLAN OF LOWER GUARD GATE.

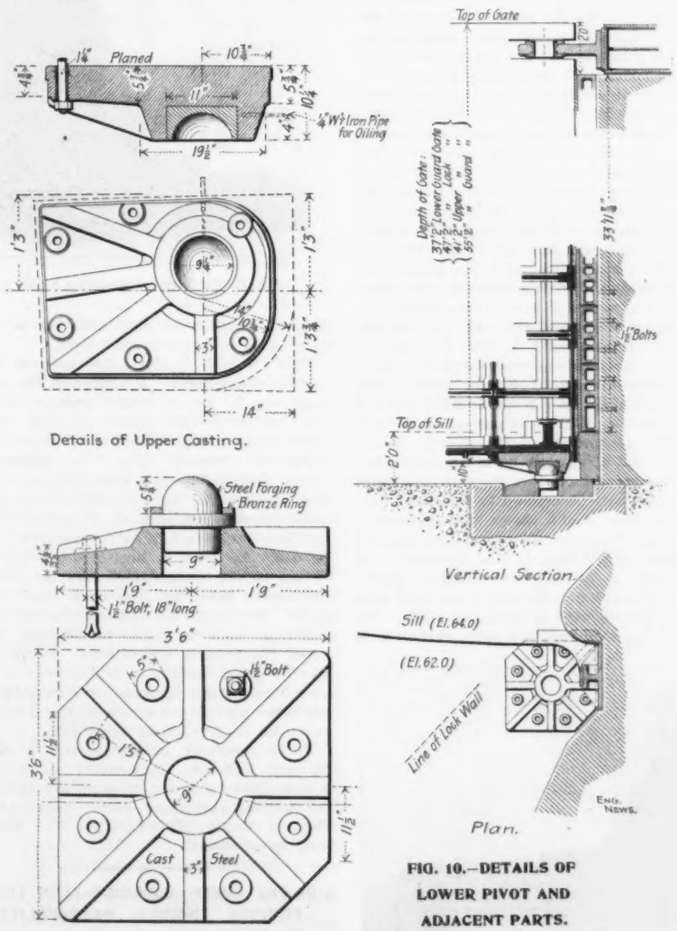


FIG. 10.—DETAILS OF LOWER PIVOT AND ADJACENT PARTS.

RAIN GUSHES IN THUNDERSTORMS.

Mr. Edgar Richardson, at Healdsburg, Colo., under date of July 27, says:

When living in West Virginia I used to observe that, during a thundershower, after every clap of thunder, the rain would come down with increased quantity for a few moments and then let up again. The whole effect seemed to be caused by the thunder discharge letting loose an increased quantity of water above. I once saw an explanation of this, but have lost it. Will you kindly explain the cause, if possible?

Several plausible methods of explaining this phenomenon have been accepted, from time to time, in the history of meteorology, but the progress of our knowledge has successively dissipated these explanations as erroneous, but without, as yet, replacing them by something nearer the truth.

One of the oldest suggested explanations was that the commotion in the air produced by the thunder jostled the cloud particles together into larger drops, that fell as rain. Generally the drops reach the ground so soon after the thunder, possibly even at the same time with it, that this explanation fails. Even the large drops would require ten seconds to fall 1,000 ft., and the clouds are much higher than that; moreover, no amount of noise, such as the firing of a gun into a small cloud of escaping steam, will produce any such formation of large drops. The idea that violent explosions can produce rain was thoroughly refuted by the famous experiments made by Dyrenforth a few years ago in Texas. Equally erroneous is the idea that has been widely believed in for several hundred years that explosions and cannonadings can break up and dissipate hailstorms, thunderstorms and rain when they are not wanted.

The rain from every cloud always comes down more or less intermittently; it may be in short, heavy showers, or in longer, gentle alternations. We do not know enough of the natural process by which rain is formed within a cloud to understand why this intermittent action should so generally occur, but anyone watching the progress of a rain cloud from some height where he may command a broad landscape, will observe it dropping its rain here and there as it moves along. Even if there were no connection, by way of cause and effect, between the noise of the thunder and the fall of the rain, yet there would always be some observers in the path of the rain cloud who would be able to say that the rain fell upon them just after they heard the thunder. There will, of course, be many more who will have observed that the rain came with or even before the thunder, and it will hardly do for us to attempt to explain the reasons why heavy rain follows the thunder until we have first satisfied ourselves that it does not equally often precede the thunder. It would take a very careful observer to accumulate the necessary statistics. He should give us the following numerical data, viz.: How many times in the course of a year has heavy rain followed after the thunder within 1, 2, or .... 10 seconds, and how many times has the rain preceded the thunder by 1, 2 or .... 10 seconds?

There can be no doubt but what thunder, which is formed simultaneously with the lightning, reaches the observer's ears some time after he sees the flash, and the editor has always thought it likely that the special showers of rain have a direct connection with the flash rather than with the thunder. So far as his own observations go, the shower has always followed the flash and not the thunder; in fact, the thunder and shower often reach us at the same time. Some very accurate observations on thunder and lightning were recorded by Mr. Stillman Masterman, of Weld, Franklin County, Me., both at that place and at Stillwater, Minn. These are published in the annual report of the Smithsonian for 1855, pages 265-282. His records give the details of each individual flash of lightning and resulting thunder. In the storm of the afternoon of July 9, 1854, the details of over 50 flashes are given, and one case is noted in which a flash, whose thunder became audible within two seconds, and was entirely over within five seconds, was preceded by the gush of rain. Similarly, in the storm of September 6, 1854, one flash was preceded by five seconds and another flash was preceded by one second by the gush of rain. On June 14 and 15, 1852, Mr. Masterman says:

I noticed that for several succeeding discharges of the electric fluid there was in every instance a sudden and violent gush of rain immediately previous to the flash of lightning. I have observed a like phenomenon on several previous occasions.

It is at present an open question whether the gushes of rain in any way bring about the formation of lightning, or whether the formation of lightning produces or accompanies the formation of the raindrops. In fact, both may be true, each under appropriate circumstances, but there is no reason to associate the thunder and the gushes of rain together as a case of cause and effect.

(1) When gushes of rain closely attend the lightning it is not improper to consider the falling rain as a mass of electrified drops conveying the electricity from the cloud region to the earth's surface; when they have approached the latter within "the striking distance," then the flash of lightning springs forth. The occurrence of the lightning is, therefore, in such cases, due to the presence of a column of descending raindrops.

(2) When the rain precedes lightning by several seconds, as in the case observed by Mr. Masterman, this explanation, of course, does not apply.

(3) When the rain follows the lightning at an interval of several seconds the connection between them may be either accidental or casual.

(3a) In the first case, the rain started from the cloud independently of the lightning and reached the observer a few seconds later, partly because it took that time to reach the ground and partly because it took time to be carried along horizontally by the wind as it fell to the earth. Both the vertical motion and the horizontal motion are involved in the time that elapses between leaving the cloud and reaching the observer.

(3b) If the connection is casual then probably the lightning and the raindrops are formed at the same instant, and the time that elapses between the observer's observation of the flash and the shower is essentially the time occupied by the drops in falling to the earth's surface.

All these suggestions looking toward an explanation of the connection between thunder, lightning and gushes of rain must be understood to be merely so-called working hypotheses, which need to be tested by further experiment and corrected, and possibly entirely abandoned.—Monthly Weather Review.

MACHINES FOR INSERTING VALVES AND BRANCHES IN WATER MAINS UNDER PRESSURE.

Patents were granted recently to Morris R. Sherrerd, M. Am. Soc. C. E., Engineer and Superintendent of the Department of Water, Newark, N. J., and to D. W. French, Superintendent of the Hackensack Water Co., Hoboken, N. J., for devices to insert valves and branches in water mains under pressure. These devices form a new departure in water-works appliances, and are

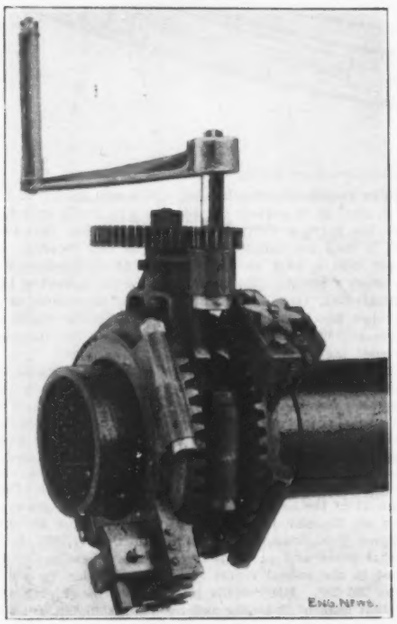


Fig. 1.—Double-Headed Cutting Tool Used with the Sherrerd French Valve and Branch Inserting Machines.

of great practical interest not only to the managers of water and gas works, but to all corporations which have to make excavations in city streets.

A brief description of the several machines employed, and of the method of operating them will be interesting to those who have experienced the inconvenience of shutting off the water supply, heretofore required when branches and valves are inserted into water mains in position.

Fig. 1 is a view of a double-headed cutting tool or a machine for cutting out a section of cast-iron pipe. This tool is used in each of the several devices. It is made up of a divided frame, the upper section of which carries the driving gear. Two similar divided collars are bolted around the central frame and mesh with its gear. This tool may be set at any point on a straight piece of pipe and is adjusted in position by small set-screws. Each collar carries a cutting tool. These are fed automatically toward the pipe upon each revolution (the collars traveling in opposite directions). The feeding is accomplished by the tripping of the small star wheels coming in contact with a stationary pin on the main frame, each star wheel being fixed to the head of a bolt in the screw-feeding blocks.

The principle involved in the several appliances for inserting valves and branches is the use of this tool within a casing temporarily attached to the main (in order that the piece may be cut out while the main is under water pressure). This machine is operated by a shaft projecting through a stuffing box in the casing, by which means the cut is made from outside the casing, and the machine and the cut-out section of pipe may be drawn up into a dome or bonnet without interfering with the flow through the mains.

Fig. 2 shows a view of a complete machine adapted for the insertion of small valves (from 6-in. to 16-in.) in cast-iron water mains. One machine can be used on two sizes of mains.

This machine is made in parts which may be bolted around the mains. The cutting tool is first placed on the main at the point where the valve is to be inserted, and the cut is partially made dry. A split sleeve is then bolted on the main around a ring of packing which fits against a shoulder on the inside of the sleeve. This sleeve is placed near one of the cutting collars. The main machine or casing is now bolted around the pipe and sleeve, completely enclosing the cutting mechanism. One end of the bottom part of the casing is temporarily leaded to the main, the other end carries a stuffing box which surrounds the sleeve. A crank shaft projecting through a stuffing box in the top of the casing is connected with the pinion of the cutting machine and the cut is completed from without the casing. The other rod shown in the view is attached to the cutting machine and also works through a stuffing box.

After the cut has been made, the cutting machine and cut-out piece are drawn up by means of the central rod into the bonnet or dome, and upon closing the horizontal sliding valve the bonnet may be removed. A valve specially adapted for this work is substituted in the bonnet for the cutting machine. The bonnet is then replaced, the horizontal valve opened, and the valve to be inserted is lowered into the space between the severed ends of the pipe and secured in place by forcing the sliding sleeve from without into the large hub of the valve and by continuing the motion the small hub is carried on to the opposite end of the cut main. The casing may then be removed.

Fig. 3 shows a valve in position after the removal of the casing, water-tight joints being maintained by gaskets, and the sleeve being held in position by jacks until lead joints are run.

The longitudinal sectional view of the valve-inserting machine, Fig. 4, gives the relative positions of the parts after the valve has been lowered between the severed ends of the pipe and just after the sliding sleeve has been pushed home. Water-tight joints are obtained by the use of rubber gaskets in the bottom of each hub. These gaskets are held in position by small wedge-shaped pieces located at intervals in the inside of each hub. The pieces also serve the purpose of centering the valve and giving uniform joint room for the lead. The water is kept from passing between the sliding sleeve and the main pipe by the use of packing wound around the pipe between the small rib on the inside of the sleeve and the valve. The sliding sleeve is operated from outside the casing by means of jacks. A water-tight joint is obtained between the sleeve and casing by a stuffing box around the outside of the sleeve. In inserting a valve the disks may be in an open position, thus allowing a free flow through the main until such a time as it is desired to use the valve.

The sectional view, Fig. 5, shows the application of the foregoing principles as adapted to placing valves in mains larger than 16 ins. diameter. In this construction the valve is made in three parts, the lower two of which carry the seat rings and are adapted to be secured around the main. An annular space is provided in this part of the valve

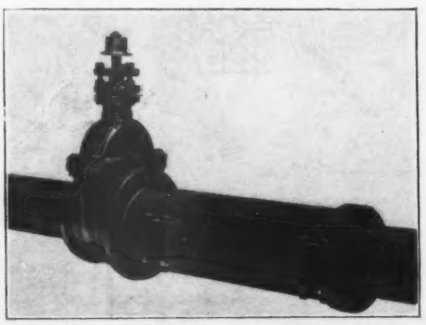


Fig. 3.—Valve and Sleeve, after Casing has been Removed.

to allow the cutting tools to revolve. By this means the valve itself is used as the casing in which the operation of cutting out a piece of pipe between the valve seats is performed. This piece and the cutting machine may be removed from the main while under pressure by the use of the bonnet of the valve as a temporary chamber to receive them. After the cut has been made, the bonnet carrying the stem, with the disks in their open position, is permanently fastened to the lower section of the valve. In opening and closing the valve the usual wedge mechanism allows the disks to pass the slightly projecting ends of the pipe where the cut was made. When the main valve is closed the auxiliary valve may be removed and

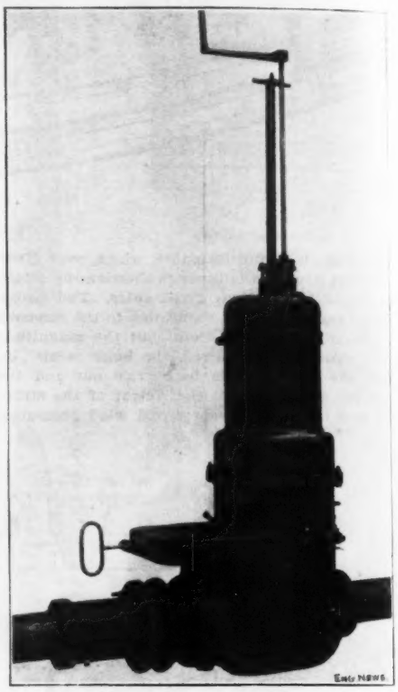


Fig. 2.—Machine for Inserting Small Valves.

a blank substituted; thus allowing this side valve to be used on other main valves.

Figs. 6 and 7 show the method of making branch connections. A section of the main line of pipe may be cut out under pressure in the center of a split or divided branch or cross. The cut-out piece and cutting machine is drawn up into a temporary bonnet. Next the sliding valve is closed and the bonnet, machine and cut-out section of pipe may be removed and a blank flange substituted. This method of making branch connections is claimed to be far superior to any now in use. It gives a better water-way, and the valves on the branch lines may be located at any convenient point, or, if desired, need not be used at all. The same cutting machine and the bonnet which is used to insert valves may be used to make the branch connections. It has the added advantage of making a double branch connection at one operation, because by removing a piece of the main pipe in the centre of the divided branch, an outlet is afforded at either side.

Valve inserting machines are in use on the Newark and the Hackensack water-works, and Messrs. Sherrerd and French are manufacturing the several appliances under their patents. Mr. Fred. A. Smith, 275 Pearl St., New York City, is their sales agent.

BIDS FOR THREE 35,000,000-GALLON LOW-SERVICE PUMPING ENGINES, METROPOLITAN WATER BOARD, BOSTON.

The Metropolitan Water Board has awarded to the Holly Manufacturing Co., of Lockport, N. Y., a contract for three vertical, triple-expansion, fly-wheel pumping engines, each having a capacity of 35,000,000 gallons in 24 hours. The specifications require that the engines shall perform a duty of 145,000,000 ft.-lbs. for each 1,000 lbs. of commercially dry steam used by the engines. The duty is to be based upon plunger displacement, but it is specified that the slip for loss of action in the pumps shall not exceed 3% of the plunger displacement. The engines are to be operated against

a total head of 45 ft., and supplied with steam of 150 lbs. pressure. If the duty shown by the engines exceeds 145,000,000 ft.-lbs., the contractor is to receive a bonus of $350 per 1,000,000 ft.-lbs. in excess of the guaranteed amount, and if the duty is less than 145,000,000 ft.-lbs., the contractor is to forfeit the sum of $1,000 for each 1,000,000 ft.-lbs. unperformed below the guaranteed amount.

The following proposals were received for the engines: Holly Manufacturing Co., $45,500 for each engine. The design submitted by this company had steam cylinders 17, 31¼ and 46 ins. in diameter by 60-in. stroke; three single-acting

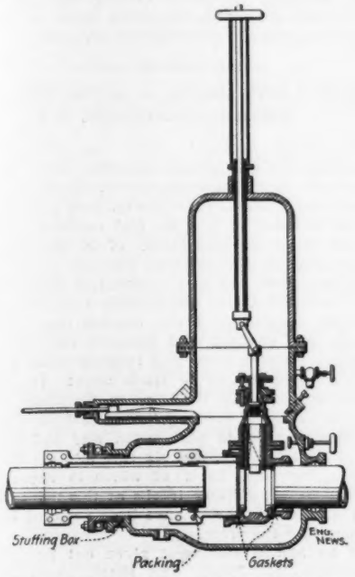


Fig. 4.—Sectional View of Valve and Sleeve.

pumps, with plungers 37 ins. in diameter and 60-in. stroke; piston speed, 300 ft. per minute.

The Geo. F. Blake Mfg. Co., of Boston, bid on two types, as follows: Type A, $67,000 for each engine; type B, $65,000. The designs submitted by this company had steam cylinders 18, 32 and 50 ins. in diameter by 60-in. stroke; three single-acting pumps, with plungers 40 ins. in diameter and 60-in. stroke. The engines were designed to have a piston speed of 254 ft. per minute.

The Edward P. Allis Co., Milwaukee, Wis., submitted three proposals, as follows: Type A, $66,000 for each engine; type B, $75,000; types C and D, $79,000. The same type of steam end was submitted with all bids, the designs varying in the types of pumps. The steam cylinders were 20, 36 and 54 ins. in diameter by 66-in. stroke. Types A, B and D had single-acting pumps, with plungers 43 ins. in diameter and 66-in. stroke. Type C had double-acting pumps, with plungers 30½ ins. in diameter by 66-in. stroke. The engines were all designed to make 20 revs. per min., giving a piston speed of 220 ft. per min.

The Lake Erie Engineering Works, Buffalo, N. Y., bid as follows: Type No. 1, $67,400; Type No. 2, $69,500. These designs had steam cylinders 19, 33 and 52 ins. in diameter by 60-in. stroke; pumps single-acting, with plungers 37½ ins. in diameter and 60-in. stroke; piston speed, 282 ft. per min. The types differ in the design of the pump chambers.

The I. P. Morris Co., Philadelphia, Pa., submitted two proposals, as follows: Single-acting plungers, $88,200; differential plungers, $89,500. These designs had steam cylinders 17, 31½ and 48 ins. in diameter by 60 ins. stroke; single-acting plungers, 37⅛ ins. in diameter by 60-in. stroke; differential plungers, 37⅛ and 26¼ ins. in diameter by 60-in. stroke; piston speed, 300 ft. per min.

Mr. Frederic P. Stearns, M. Am. Soc. C. E., is Chief Engineer of the Metropolitan Water Board, and Mr. Dexter Brackett, M. Am. Soc. C. E., is Engineer of the Distribution Department. We are indebted to Mr. Brackett for the above information.

SEWAGE DISPOSAL ON LAND AT LITCHFIELD, CONN.

Sewage disposal on a small scale was begun at Litchfield, Conn., in 1892, and has been continued with some changes and enlargements since. But

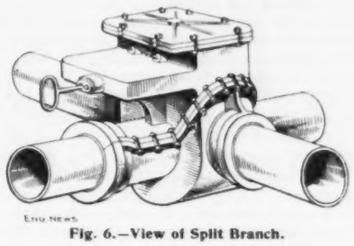
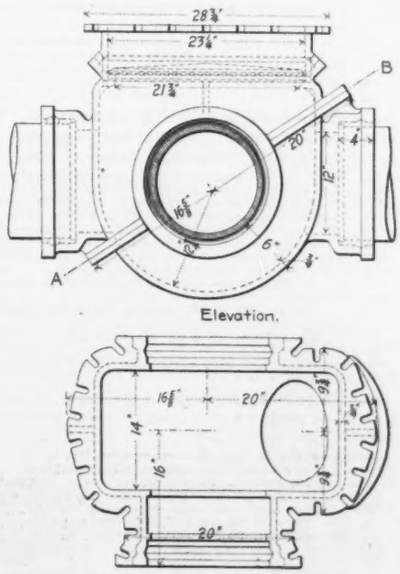


Fig. 6.—View of Split Branch.

little expense has been put on the disposal area, but it is said to give satisfaction.

Litchfield had a population of 1,058 in 1890, during which year water-works were built by a private company. About 1890 the borough applied to the legislature for authority to take land outside its limits for sewage disposal purposes, Mr. T. H. McKenzie, M. Am. Soc. C. E., of Hartford, Conn., having prepared plans for filter beds. The legislature adjourned without acting on the application, and authority to use this land was never secured. In 1892 the borough laid about three miles of pipe sewers, providing for a hotel, about 80 dwellings and a few other buildings. About three acres of land were bought for a disposal area, less than one acre of which was suitable for receiving sewage. Several beds were laid out, but not underdrained, and were put in use. Owing to the unsuitable character of the soil the beds could not absorb the sewage fast enough in wet weather to prevent ponding.

In the fall of 1894 the sewerage system was extended to provide for the whole village. All the sewage could not be conveyed by gravity to the old beds, besides which the land was unsuitable, so an area of 17 acres was bought in another location, about three miles southwest of the borough. The new area cost about $500. The old field has been sold. In December, 1895, Mr. Wm. Marsh, Sewer Commissioner, informed us that about two acres of the new field had been divided into beds and partially graded and was then taking care of the sewage satisfactorily, except in very wet spring and fall weather. At such



times, he stated, the volume of sewage was largely increased by roof and other storm water, overtaxing the beds. On Oct. 7, 1897, Mr. Marsh wrote that the storm water has been almost entirely diverted from the sewers. Some work is done on the field each year in the way of thorough grading and otherwise preparing it for use.

The sewage is distributed by means of wooden carriers having side gates 20 ft. apart. The soil of most of the field is a light, sandy loam, in which the sewage speedily disappears. No underdrains have been provided as yet. Mr. Marsh states that the effluent finds its way into low, swampy ground on three sides of the field. He also says that it has not yet been found necessary to give the beds as elaborate preparation as has been the case at some other places, the sewage being cared for "in fine shape," and, again, "in a very satisfactory manner." Of course, such statements as these give no idea of the real efficiency of the beds, although indicating that they are a nuisance to no one and work to the satisfaction of those in charge. Probably there are not many houses near by, for the beds are some three miles from the village; in addition, Mr. Marsh states, in answer to a question regarding the raising of crops, that no attempt at cropping has been made,

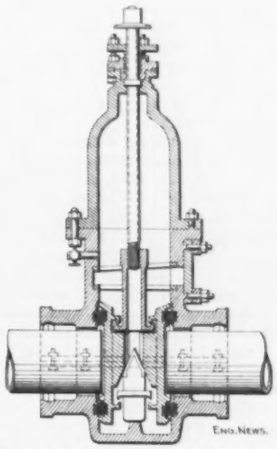


Fig. 5.—Sectional View of Large Valve.

"but I am sure it might be done to advantage if any one lived near the field who could attend to it."

The engineering work connected with laying out the sewerage system was done by Mr. C. J. Hill, of New Haven, but the beds have been con-

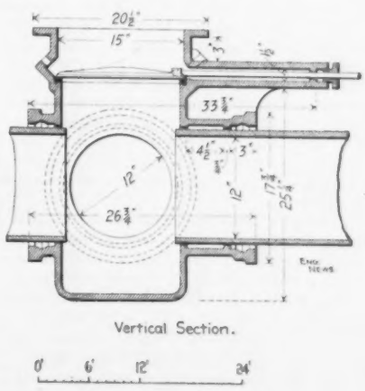


Fig. 7.—Details of Split Branch.

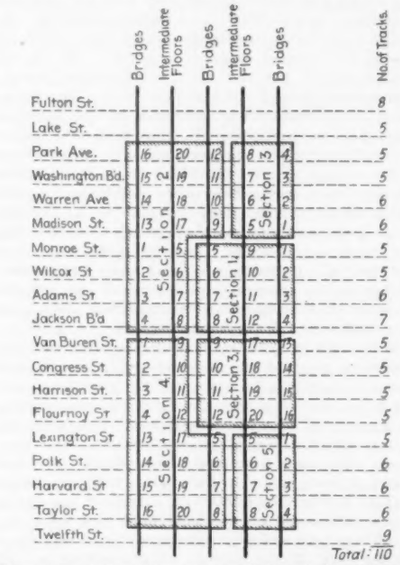
structed since then, perhaps in part from grades and lines established by Mr. Hill. The whole system, as we understand it, is in charge of Mr. Marsh, to whom we are indebted for most of the information given above.

THE KNAPP ROLLER BOAT, which was recently launched at Toronto, Ont., was tested on Oct. 21, and attained a speed of about six miles per hour, according to the press dispatches. The test was discontinued after about two miles had been traversed, as the plates of the cylinder showed signs of weakness. As stated in our issue of Sept. 23, 1897, this vessel consists of two cylinders, an inner one carrying all the machinery, supplies, etc., and an outer cylinder provided with paddles. The inner cylinder is supposed to maintain its position while the outer cylinder revolves, causing the vessel to progress by actually rolling over the water.

PROGRESS OF TRACK ELEVATION BY THE CHICAGO & NORTHWESTERN RY. IN CHICAGO.

Some rapid work in track elevation at Chicago has been accomplished by the Chicago & Northwestern Ry. in its work of abolishing grade crossings in conformity with the city ordinances. While the work has been spread over about 2½ years, it has been in actual progress only a few months at a time, during the spring and summer of each year, the total time of work aggregating only about eight months, or one or two miles of work per month. Practically all the work consists of solid embankments 8 to 12 ft. high, wide enough for 3 to 9 tracks, the embankments having heavy masonry retaining walls. The streets are crossed by plate-girder through bridges, which were erected on pile abutments before the masonry abutments were built, and many of the streets have been lowered from 4 to 6 ft., requiring excavation and paving. As all the work involves busy main lines, yards and junctions, with heavy traffic, and as it had to be carried on as rapidly as possible, and with little interference with railway or street traffic, it has required very careful planning and management. All the work has been laid out by and carried on under the supervision of Mr. L. H. Evans, Engineer of Track Elevation for the C. & N. W. Ry. The work was commenced on May 11, 1895, on the Galena Division, and this part was completed by July 17, 1895, eliminating all grade crossings between Western Ave. and 47th Ave., a distance of about 3 miles, 1½ miles being elevated. The railway has five tracks for a part of the distance, and nine tracks for the rest of the distance, and there are seven street crossings. This would be about 45 days per mile of line (with five street crossings per mile). On June 18, 1896, work was commenced on the elevation of the Milwaukee Division, and by July 31, 1896, 2¼ miles had been completed. The remaining 1½ miles of this division were commenced April 15, 1897, and completed May 10, 1897. This division had a double track, but a third track was built during the work of elevating the line. On the first part of the work there are 13 street crossings, while the track was raised 8 ft. and the streets lowered 4 to 6 ft. below their former grade. On the second part, 1½ miles, there are eight street crossings. This would give 19.1 days per mile (with 5.5 street crossings per mile) for the first section; and 16.6 days per mile (with 5.3 street crossings per mile) for the second section. On June 1, 1897, work was commenced elevating the line from the Galena Division along Rockwell St. to Twelfth St., 1½ miles, this division including three tracks of the Chicago & Northwestern Ry., and two tracks of the Pittsburg, Cincinnati, Chicago & St. Louis Ry., the latter being parallel with and alongside of the former. This part of the work was completed Aug. 16, 1897, giving 51.4 days per mile of line, with about 13 street crossings per mile. The accompanying table shows the extent of the work and its rate of progress:

On the Rockwell St. line there are 19 bridges over street crossings, the spans being from 66 to 100 ft., and most of these carry six tracks. Much of the bridge work was done at a very rapid rate, the manufactured bridge material being assembled at derricks placed at one end of the work, and then loaded onto cars as complete bridges. These were then hauled to the street and lowered upon temporary pile supports, the masonry abutments being built afterwards, while the elevated tracks were in operation. The intermediate floors were then put in place. The work of elevation was done in sections of such lengths as to include four street crossings, and two tracks were raised at a time. The C. & N. W. Ry. trains used the P., C., C. & St. L. Ry. tracks for 23 days, and the latter trains used the former tracks for 52 days, traffic being thus interchanged for 75 days, during which time 110 tracks were elevated over the streets. The general scheme of the bridge erection work is shown by the accompanying diagram, the numbers on which represent the bridge spans in the order of their erection. From this it will be seen that there are practically three sets of bridges, side by side, connected by two sets of intermediate flooring to form a continuous width of bridge. This work was handled as if it were a five-track railway, and the bridge for the extra tracks are not always connected with the main bridge. All the bridges are for single-track, 13 ft. c. to c. The masonry is built for seven tracks, and where there are six tracks on the bridges there is a space for floor



Plan of Track Elevation work on Rockwell Street Line, in Chicago, Chicago & Northwestern Ry., showing the Order in which Structures were Erected.

(The numbers on the diagram show in each section the order in which the several bridge spans and intermediate floors were erected. The numbers given to the sections show the order in which the work was done.)

for another track to be put in when needed. The rapid rate of the progress of the work may be gathered from the following summary:

Sec. No. 1.—Equivalent to 12 tracks; first bridge placed June 4, and section opened for traffic at 2 p. m., June 12.

Sec. No. 2.—Equivalent to 20 tracks; first bridge placed June 13, and section opened for traffic at 6 p. m., June 25.

Sec. No. 3.—Equivalent to 20 tracks; first bridge placed June 26, and section opened to traffic at 6 a. m., July 12.

Sec. No. 4.—Equivalent to 20 tracks; first bridge placed July 12, and section opened for traffic July 22.

Sec. No. 5.—Equivalent to 8 tracks; all work done on July 22 and 23.

From June 4 to July 23 (37 working days), bridges were placed for 83 tracks over subways.

At 12th St., bridges for 7 tracks were put in between Aug. 1 and Aug. 6.

At Lake and Fulton Sts., bridges for 13 tracks were put in between Aug. 9 and 15.

A brick passenger station of the P., C., C. & St. L. Ry., at Madison and Rockwell Sts., had to be raised about 15 ft., and two elevated railways had to be raised to give the necessary headway. The work of elevating the Metropolitan West Side Elevated Ry. was described in our issue of Sept. 30. As the Lake St. Elevated Ry. did not require to be raised as much as the other line, on account of the C. & N. W. Ry. gradually descending to its old grade, the tracks of the elevated railway have been left at the same elevation, but a through-truss span has taken the place of three plate-girder deck spans. The Chicago & Northwestern Ry. has now elevated about seven miles of its tracks, and next April it will begin work on the Wisconsin Division, between Mayfair and Clybourn Junctions, 4½ miles, on which there will be 25 street subways or 5.5 crossings per mile.

Table Showing the Progress of Work of Track Elevation in Chicago by the Chicago & Northwestern Ry.

Items.	Galena Division.	Milwaukee Division—1st section.	Milwaukee Division—2d section.	Rockwell St.	Total.
Length, miles	1½	2¼	1½	1½	6¾
Number of tracks	5 to 9	3	3	5	.....
Work commenced	May 11, '95	June 18, '96	April 15, '97	June 1	.....
Work finished	July 17, '95	July 31, '96	May 10, '97	Aug. 16	.....
Days of work	67	43	25	77	258
Days per mile of line	45	19.1	16.6	51.4	31
Streets crossed	7	13	8	19	47
Streets crossed per mile	5	5.5	5.3	13	6.6
Miles of double track	3.75	3.37	2.25	3.75	13.12
Filling bank, cu. yds.	275,000	140,000	110,000	190,000	715,000
Excavation for streets, cu. yds.	30,600	57,000	35,000	70,000	192,600
Masonry for retaining walls and abutments, cu. yds.	10,170	8,530	5,000	20,000	43,700
Ballast, cu. yds.	53,000	32,000	13,000	35,000	133,000
Rails, tons	1,089	285	188	1,200	2,762
Bridges, tons	1,645	1,995	1,184	6,000	10,824
Street paving, sq. yds.	11,433	18,600	11,000	32,000	73,033
Sidewalks, sq. yds.	6,833	8,950	4,300	21,000	41,003
Average number of men (including excavation, filling, masonry, piling, bridge work, ballasting and track-laying.	350	350	350	400	.....

THE NEW YORK CENTRAL & HUDSON RIVER R. R. WRECK NEAR GARRISONS, N. Y.

The worst accident which has occurred on the New York Central & Hudson River R. R. since the New Hamburg disaster of Feb. 6, 1871, in which 21 persons met death, took place in the early morning of Oct. 24, and resulted in the death of 20 and the injury of 14 persons. In some respects the accident was one of the most peculiar which has ever occurred in this country. The wrecked train, the Buffalo and New York Special, consisting of one express car, one day coach, one baggage and smoking car, and six Wagner sleeping cars, was running along a level and straight stretch of track about 1½ miles south of Garrison's, N. Y., when, seemingly, without an instant's warning, the embankment of the roadbed appears to have given way and precipitated the locomotive and six cars into the Hudson River, the east bank of which is approached closely by the railway tracks at this point. Most of the killed appear to have been drowned by the plunge into the river.

In an official statement given out by General Superintendent Edger Van Etten, about twelve hours after the accident, the following particulars of interest are found:

> The accident to train No. 46 this morning, two miles south of Garrison's, was caused, to the best of our belief, by the embankment slipping into the river under the weight of the engine. Why this embankment, which has stood for 40 years or more, should give out at this particular time, is unaccountable. Trains in both directions had passed over it within 15 minutes of the time the accident occurred, one northbound within 30 minutes.
>
> The engine and tender went into the river, dragging with them the express car, the combined baggage and smoking car, the day coach and three sleeping cars, leaving three sleepers standing upon the rails. There were upon the train 96 passengers, five trainmen, and eight employees, 109 persons in all.

Later investigations have added only a few minor facts regarding the character of the wreck and the fatalities caused by it. The cause of the accident is yet very largely a matter of conjecture, but as is always the case in such instances, a vast number of widely varying explanations and theories have been advanced. The more important of these will be given following a brief statement of the physical conditions of the track and roadbed at the point where the accident occurred.

The site of the accident was about 1½ miles south of Garrison's, a station 50 miles north of New York, and about two miles north of Highlands, the next station south of Garrisons. The road between the two stations is pretty crooked but at this spot, midway between them, is a straight, level stretch of track, about half a mile long. The road is double tracked, the precipitous sides of the Fishkill Mountains coming down almost to the edge of the roadbed on the land side and the waters of the Hudson River being only 15 ft. or 16 ft. from the outer rail on the river side. As stated by General Superintendent Van Etten, trains had passed safely over this outside track within 15 minutes of the time of the accident. The clearest and probably the most authoritative statement of the construction of the roadbed at the point where the break took place has been made by General Roadmaster W. D. Otis and published in some of the New York daily papers. This statement, as given in the New York "Times," is as follows:

> I have noticed a report that we have been widening out the roadbed at the point where the accident occurred, and that in so doing we built an unsubstantial wall on sandy bottom without driving piles. I wish to say that

that report is absolutely false. The facts in the case are these: Before the road was built there was a little cove at the place in question. It extended to the east some 30 ft. beyond the east side of the present roadbed. The formation of the earth at the bottom was rock. It came down from the hills to the east, and curving under the pool, started off down into the river.

When we came to lay our road there 45 years ago, using that solid rock as a bottom, we filled in the space across the cove with rocks taken from cuts which had been blasted out. The sea wall was built at that time, using this same rock surface as a basis. That sea wall was still in existence on Saturday night. The work that we have been doing there lately consisted not of widening the bed out toward the river, but of raising the surface of the bed.

We have frequently to do that, as the roadbed in spots like that continually tends to sink. In raising the bed we did not, however, widen it or change the alinement of the tracks in any way. Raising the bed, however, naturally necessitated the raising of the sea wall. We built the new wall on top of the old wall, using the old wall as a foundation. The alinement or construction of the old wall were not changed in any particular. Its top came in some places above the surface of the water; in others it was just below the surface.

The new wall, reared on top of the old one, was simply a piece of masonry above the water, and its giving away would not have occasioned any such accident as occurred.

I should say that at some points along the line where we were raising the roadbed we found the old sea wall slightly bulged out. It had been forced out by the pressure of the filling in.

The bulging, however, was only noticeable near the top of the old sea wall. Further down, near the foundation, it had not moved an inch from the position in which it was originally laid, and consequently the bulging was of no consequence whatever. Any bulging of this kind was noticeable wherever the new superstructure was laid in such way as to make a straight string-piece.

Of course, it is next to impossible to say exactly what caused the accident. At the same time, knowing the treacherous character of slanting rocks, full of cavities and ledges, I think it quite possible that the rock formation beneath the roadbed and beneath the original sea wall gave way.

We have discussed the principal points of Mr. Otis' statement in our editorial columns, and will not refer to it further here. As already stated, several theories have been advanced in regard to the cause of the accident.

The first and most common theory is that the river waters raised by the high tides of the few days preceding the accident had penetrated the sea wall and washed out parts of the earth filling of the roadbed, leaving simply a crust on top, or, at least, had caused fissures and cavities, so that the load caused a subsidence and the whole embankment next to the river slumped out. It is pointed out that the wall, which was not designed as a retaining wall but simply as a sea wall, to prevent the waves from washing the embankment, was a dry wall, that is, without mortar joints, so that the access of the water to the filling inside was easy. We have discussed this and other probabilities in our editorial columns.

Immediately after the accident work was begun by the railway company repairing the track and raising the sunk cars and locomotive. In repairing the roadbed both tracks have been swung in shore, so that the outside or river track now occupies the position of the former inside or inshore track. An investigation of the accident is to be made by the State Railroad Commission, and it is hoped that it may shed further light upon the causes of the disaster.

A PAN-AMERICAN EXPOSITION to illustrate the material progress of the New World during the nineteenth century is proposed to be held at some point on the Niagara River in the State of New York in the year 1900. The idea is stated to have been suggested at the Atlanta Exposition by the American Exhibitors' Association, and to have been taken up by Capt. J. M. Brinker and Richmond C. Hill, of Buffalo, N. Y., who have organized the Pan-American Exposition Company, with a full list of officers and an executive committee to prepare plans and proceed with the necessary preliminary work. The site for the exposition is stated to be at La Salle, about four miles south of Niagara Falls on the Niagara River. Among the people connected with the scheme are Messrs. Chauncey M. Depew and Roswell P. Flower.

THE SIXTEENTH ANNUAL CONVENTION OF THE AMERICAN STREET RAILWAY ASSOCIATION.

The 16th annual convention of the American Street Railway Association was called to order by President Robert McCulloch at Niagara Falls, N. Y., on the morning of Oct. 19. The President introduced Hon. A. C. Hastings, Mayor of the city, who welcomed the visiting street railway men in a brief address, during which he outlined the history of Niagara Falls and the plans for power development which may in the future result in transmitting current as far even as New York. The President's brief, but well turned reply was followed by the roll-call, which showed a good proportion of delegates present.

The President then announced that 11 street railways had requested membership previous to the meeting. The minutes of the last meeting, held in St. Louis, in October, 1896, were approved, and President McCulloch then read his address, in the course of which he spoke of the increasing use of Niagara's power for railway purposes and the constant and rapid changes in design and construction of apparatus. He enumerated the objects of the society and reasons for the meetings, and complimented the supply men for contributing so largely to the success attained. The Street Railway Accountants' Association, then in session in a lower room, was mentioned in high terms. Mr. McCulloch advised that all subjects selected for consideration should be such as would tend toward advancement of the science of railroading rather than those of a historical nature.

The deaths of five delegates occurring during the past year were announced. The President was authorized to appoint a committee to draw up and publish suitable resolutions. Mr. Penington next read the Secretary's and Treasurer's report, which showed the association to be on a sound financial basis.

A resolution was adopted that the Association endorse and pledge its support to the Street Railway Accountants' Association.

The convention then began the program of papers on technical subjects. In the absence of Mr. P. F. Sullivan, General Manager Lowell & Suburban Ry. Co., Lowell, Mass., the Secretary read his paper, entitled "Municipal Ownership of Street Railways." The paper made comparisons between American systems owned by private companies and foreign and local municipal systems, and the questions of rascality and political reward, etc., were well illustrated. A summation of opinions expressed by a number of prominent men throughout the country was given. These were in general to the effect that great corruption existed in American municipal affairs, and as examples the Union Pacific, the Erie Canal and other Government works were mentioned. Another important fact emphasized by the speaker was the great difference in track mileage, American cities having a much greater mileage of street railways than European cities of similar size. It was stated, also, that smaller fronts were made there.

In the discussion of this paper, Mr. Rogers, of Binghampton, N. Y., knew of only two ways in which a municipality could obtain possession of private roads—by taxing out of existence or by actually taking a road away from its owners. It was a question between politicians and the people, and if they should take possession by any process, would they reimburse for the losses incurred before a road was on a paying basis? Mr. Bean read a clipping from a Detroit, Mich., paper stating that at the recent convention of Mayors at Columbus, O., the municipal ownership of street railways was favored. In addition, he stated that in some States the authorities could take possession by paying; in others they could not until the franchise expired. In Michigan they had the power to parallel, and thus destroy the value of a privately owned road. The question of printing this paper for general distribution was raised, and after considerable discussion it was left to the Executive Committee, with power to act.

The President then introduced Mr. G. W. Knox, Electrical Engineer Chicago City R. R. Co., whose paper was entitled "Some of the Difficulties Existing in the Construction and Operation of Electric Street Railways." The following abstract gives the principal points touched upon:

Many an electric road now in the hands of a receiver could be making neat incomes for the investors had a closer study and practice of the economic principles governing the details of construction and operation been made. The keynote of doing this lies in lopping off here and there the many unnecessary extravagances existing in the various departments of the system. The first and most important step in working out economies is in selecting a corps of operators, from the head foreman down to the man sweeping out the depot. If they are interested, and are working for the good of the company, scarcely an hour of the time in which they are engaged can go by without their effecting little savings, which in time swell the items of economies to mammoth proportions.

Our engines and electrical machinery have reached a state of comparatively high efficiency and economy, and there is not so much chance of making the saving along these lines, in either design or operation. There is also but little chance, in a broad sense, for argument upon such questions as feeder requirements, the necessity of ample and absolute return, cars, motors, etc.—as a general idea of what is required is so well understood.

There are immense sums of money needlessly squandered in supplies and repairs for an electric road in a year. One of the causes of this waste lies in the fact that the roads have not yet arrived at a standard in the design of the apparatus which they use, to which too much importance cannot be attached. I mean in no wise to decry the assiduous and most excellent work of the manufacturers of electrical apparatus, but the unwary railway man has had an immense amount of experimental claptrap machinery inflicted upon him, all of which has cost dearly.

Shaving of prices on material to the extent that it has resulted in competition being so sharp among the manufacturers of electrical supplies that they have adopted the piece work plan in order that cheapness may be secured, thus turning out upon the market apparatus that makes no claims for efficiency, but is produced to fill orders. To free ourselves of these troubles, we must be more careful in getting out the specifications and checking up the material received. The most carefully prepared detail specifications should go out for every piece of apparatus used. You will then find that your supplies are coming to you made up in the proper manner. To be able to get out the specifications needed, it requires a certain amount of experimental work, requiring the keenest discretion. Experimental work should only be encouraged to the extent of having in view the elimination of an existing money-wasting evil, and allowed only as passed upon by the management of the road, who should be fully competent to determine the probable practicability of the theory proposed.

I would strongly advocate not getting too great a quantity of stock of any kind of material on hand, as the defects developing often require the complete changing of designs, with consequent scrapping of all material in stock.

Another serious difficulty to be considered in connection with operation is the inefficiency of the motormen, and the Board of Examiners for the fitness of employees on street railways will be able to make a better showing in efficient operation than most other departments by giving more attention to the examination and instruction of operators.

One of the most commendable practices in street railway management is the regular calling together of the heads of the different departments for consultation on matters pertaining to their respective departments.

During the discussion which followed, Mr. Littell, Buffalo, N. Y., stated that he considered the meeting of heads of different departments a most excellent idea, and that he had been practicing it for some time with good results. The meeting then adjourned until the morning of Oct. 20.

While the delegates were in session at Convention Hall the lady visitors were entertained by an enjoyable tally-ho ride across the suspension bridge to the points of interest on the Canadian side, through the courtesy of the General Elec. Co., and later in the International Hotel parlors by the local reception committee.

The afternoon was devoted by nearly all to inspection trips, which included visits to the power house of the Niagara Falls Power Co., the Carborundum Works, the Pittsburg Reduction Co.'s large plant and the power plant of the Niagara Falls Power & Mfg. Co. In the evening the ladies' reception committee gave an entertainment in the parlors of the International Hotel, which included music and dancing.

At the opening of the second day's session the Secretary announced that there were then in attendance about 500 delegates, 100 ladies and fully 600 supply men. Mr. Charles Hewett, Electrical Engineer Union Traction Co., Philadelphia, Pa., then read a paper entitled "Application of the Storage Battery to Electric Traction." The following is an abstract:

The most important applications of the storage battery to electric traction are:

1, the application of the battery direct to car or locomotive; 2, the application of the battery at points on the line distant from the generating station; 3, the application of the battery in the power house.

With the application of the battery direct to car or locomotive, the first cost is greater than our present overhead form of construction, and the expense of operation is considerably greater. It is less reliable and more objectionable to passengers on account of the gas given off. But very little reliable data is obtainable from all the various experiments which have been made. Mr. Dawson in an article published in "Engineering," Oct. 16, 1896, says: "Two principal causes have so far prevented the successful use of the accumulator cars—their great weight and rapid deterioration of plant—and although manufacturers have been working on the problem since 1880, little reliable information has ever reached the public."

I feel confident in stating that the battery car requires considerably more power to operate than an ordinary trolley car of the same size and under the same conditions, and, further, the battery car will require a larger investment in generating machinery. In fact, unless some form of battery be discovered with entirely different characteristics from the lead battery, I should advise leaving such experiments to those who enjoy spending money on this kind of a hobby. Every battery has what may be termed a critical rate of discharge. From zero up to the critical rate the working e. m. f. remains practically constant. For any particular battery there is a rate of charge which cannot be exceeded without useless waste of energy. If we plot curves for charging and discharging at normal or critical rate the space between the curves will represent waste energy. You will appreciate, therefore, the remarks of Sir David Salomon, "that it takes power to get current through the battery, and it also takes power to get the current out." These critical rates of charge and discharge seem to be partly due to the time required for the chemical reactions in the battery to take place. The physical limitations of a car require the battery to have a large output for its weight and bulk. To obtain this it is necessary to increase the surface of active material as much as possible, and to decrease the inactive supporting grid. In consequence, the battery plates become mechanically weak. The conditions seem to prevent the making of plates large enough to prevent exceeding the critical discharge rate, and which are at the same time light enough and small enough to be carried on a car. The inherent characteristics of the lead battery are such that it is very doubtful whether it will ever be successful in propelling cars unaided by other sources of power.

There is another phase of this method of application which is used somewhat extensively in Europe. In some of the larger cities on the Continent there is a prescribed area within which overhead lines are not allowed to be erected. To overcome this difficulty the cars are supplied with batteries sufficiently large to propel them at a low rate of speed for a distance of three or four miles from the point where the overhead line ends, into the city and return. While the cars are completing the trip the batteries are charged from the overhead wire. I am sure such an arrangement would not commend itself to any practical railroad manager, except as a makeshift in such government-ridden cities as exist in Europe. I feel satisfied that the extra cost of feeder cables, due to the extra power transmitted and the decrease in efficiency, will more than offset any saving in cost of linework, while the cost of operation must be, and is, acknowledged to be in excess of the less complicated system in common use in this country. There are only two cities in this country where a combined storage battery and trolley system

might reasonably be considered, and in those cities the slotted conduit has been adopted.

The following data are taken from the writings of Mr. Dawson and others:

Data of Accumulator Line at the Hague, 1891.
Julien Accumulators.

Length of line	3.5 miles.
Mamimum grade	1.50
Weight of car loaded	14 to 16 tons.
Number of cells	192
Weight of cells	4 tons.
Maximum speed in miles per hour	12.5
Maximum distance run with one charge	44 miles.
Average distance run with one charge	35 "
Capacity of cells in ampere hours per lb. of plate	4.5
Positive plate can run with't renewal	9,000 to 11,000 miles.
Cost of maintenance of cells per car mile	8.5 d.
Cost of handling cells per car mile	2.3 "
Kilo-watt hours consumed per car mile	1.080
Probable maximum discharge rate	130 amperes.

Cost, per Car Mile, of Running Accumulator Cars in Birmingham, England, in 1893:

	Pence.	Cents.
Wages	3.37	6.74
Fuel	1.76	3.52
Stores	.68	1.36
Water and gas	.12	.24
Sundries	.17	.34
Repairs and main	5.49	10.98
	11.59	23.18
Car miles run	140,993	

Working Expenses, per Car Mile, of Accumulator Traction in Paris, in 1893:

	Pence.	Cents.
General expenses	.204	.408
Cost of power	2.828	5.656
Maintenance and handling of accumulator	2.537	5.074
Motormen and assistants	1.210	2.420
Maintenance of motors and trucks	1.410	2.820
Heating, lighting and various	0.138	.276
	8.327	16.654
Miles run	144,718	

Comparative Cost, per Car Mile, of Various Systems of Traction in Paris:

Horses	17.10 cts.
Accumulator	16.66 "
Hot water locomotives	10.78 "
Overhead trolley system	9.24 "

A third phase of the battery car system is the battery locomotive, in which the battery is connected in multiple with the motors and charges or discharges according to the demands of the train. This system has the advantage of maintaining a fairly constant pressure at the motors, but this can be accomplished better in other ways.

In the application of storage batteries on the ends of long lines, the conditions are entirely different. The battery in this case acts essentially as a pressure regulator. The conditions do not restrict the size of the plates, so that the plates can admit of such a size that the current density on discharge can be kept well within the limits of normal discharge; and in consequence of this the battery is not subject to the great loss of efficiency, due to the fall of e. m. f. on discharge.

The only system of this kind used in any of the large cities for suburban service is the one installed by the Union Traction Co., of Philadelphia, Pa. The phenomenal increase in travel necessitated a large increase in the car service, and the success of the line warranted its extension from time to time, until it now terminates 11.2 miles from the power house. The drop in pressure over this long line made it impossible to run the requisite number of cars, as the speed of a trolley car is approximately in the direct ratio to the applied e. m. f. The cables for feeding this section consisted of three 1,000,000 circular mils, copper, rubber covered and leaded cables, laid in terra cotta ducts. The investment in feeders for this line had reached a point considerably above $100,000, not including the conduits. To have increased the cable system properly would have required about 336,000 ft. of 1,000,000 circular mils cable. At $1.05 per ft. laid, this would amount to $352,800; deducting the value of cables which were already laid, and which are estimated at $79,000, we find that the extra cost for cables, without conduits, would have been $273,800; this figure is, of course, prohibitory.

It was necessary, therefore, to furnish some means to keep up the pressure. If a station had been built at that point it would of necessity have been small and insufficient—about 750 K-W. capacity. Such a station would have cost about $85 per HP., or a total of $85,000. A battery station, on the other hand, required but little real estate, would be inexpensive to operate, and its cost would be considerably less than a power station. The entire cost of the battery plant, real estate and building was approximately $25,000. To this must be added the cost of a booster in the main power house. This required a 200 K-W. generator, which, with its engine, would cost about $8,000. The total cost of battery and booster would, therefore, have been $33,000. We find, therefore, that, deducting $33,000, the cost of the battery and booster, from $85,000, the cost of a station, that the difference in first cost is $52,000 in favor of the battery.

Cost of Operating.

From volt and ampere meter readings, taken from the power house in October, 1896, we find that 136,576,919 watt-hours were delivered to the line at the battery house. These figures, I may explain, do not include the watt-hours generated by the booster, since we have assumed that this entire amount is lost in transmission. As a matter of fact, this is not strictly correct; but if a station were operated at Chestnut Hill it would be run at a bus bar pressure a little above the battery pressure, and therefore, for our present purposes, the assumption is correct. From our experience in operating power houses of various capacities, we find that a power house operated at Chestnut Hill under conditions which I have described would cost about 1½ cts. per K-W. hour. We therefore get the following as the cost of generating the number of K-W. hours required by the Chestnut Hill branch during the month of October, 1896, if furnished by a station at Chestnut Hill:

184,848 K-W. hours, at 1½ cts.	$2,022.73
Interest on $85,000, at 5% per annum	354.17
Depreciation on machinery, etc., at 5% per an'm.	354.17
Insurance, taxes, etc.	200.00
Total cost of operation for the month by direct methods	**$2,931.07**

Actual Cost of Operating the Battery and Booster.

Watt-hours delivered by bus bar	136,576,919
Watt-hours generated by booster	34,234,648
Total watt-hours delivered to cable	170,811,567

The cost of operating the power house for the month of October, exclusive of interest and depreciation, was 7 mils per K-W. hour. Therefore, we obtain the following:

170,811,567 K-W. hours, at 0.7 cts.	$1,195.68
Cost of labor and supplies at battery house	179.73
Total	$1,375.41
Depreciation of battery, at 5% per annum	83.33
Interest, at 5% per annum on $33,000	137.50
Taxes, insurance, etc.	32.00
Total cost of operation	$1,628.24

Deducting this from the cost of operating by a station at Chestnut Hill, we find the difference in favor of the battery for the month would be $1,302.83.

Since Oct. 1, 1896, the method of operating has been somewhat changed, and by installing watt meters the following data has been obtained:

Total cost for May, 1897, by direct method	$2,454.14
Total cost of operating battery	1,100.76
Saving resulting from use of battery	$1,353.38

During this period the average efficiency was 85.5%.

Application of Battery to Power House.—This form of installation has not become very generally appreciated in this country. The wide fluctuations in load in railway power houses is now well known. The average daily load varies from 50% of the maximum in small stations to 70% of maximum in the largest stations. From a large number of observations in all parts of the country, the average load is very close to two-thirds of the maximum load. Now, it is also well known that the maximum economy of the steam engine exists for a very small range of load, and that on each side of the point of maximum economy the efficiency falls off—rapidly on the overload, somewhat less rapidly on the underload. The result is apparent. In most stations the engines, at the best, have an average load of only two-thirds their most efficient load, and, as a consequence, consume over 4.5 lbs. of coal per K-W. hour.

With badly regulated engines, and especially with water power plants, the changes in load are accompanied by variations in speed and consequently in voltage. These troubles may be entirely corrected by installing a battery.

It is necessary that the capacity of the battery should bear a larger ratio to the output of the station than is necessary for potential regulation, as described in the previous section of this paper. In potential regulation a comparatively small battery is necessary, since by changing the potential of the booster from time to time during the day the charge and discharge can be kept very low. For load regulation, however, the battery could have a capacity equal to one-third the maximum output of the station. The average load of the station may then be made the maximum load of the engines, the battery taking care of the fluctuations.

In discussing the paper Mr. McFayden asked if batteries, boosters or a combination would prove most satisfactory in keeping up the voltage of long feeders. In reply Mr. Hewett said that all small stations could be operated better with batteries. He also said that the manufacturers of the accumulator used by his company had guaranteed them for 10 years. A battery is useful when the fluctuations of load are sudden and considerable, and a booster operates best when a heavy load is more or less gradually thrown upon the system. It was suggested that batteries could be placed upon a flat car, charged at the station and run out to where the greatest load was apt to occur. In this case Mr. Hewett replied that it was simply the cost of batteries against the cost of feeders. He also stated that it was next to impossible to say off-hand which system was the cheaper, battery or booster.

Referring to a storage battery plant on the Easton, Pa., electric railway Mr. Hewett said that at present three engines are doing the work formerly requiring four. The three are working at their best economy and give, probably, a saving of fully 20% in fuel.

Mr. Ely, Niagara Falls, explained that the Buffalo City Ry. contracts with the Niagara Power Co. for a certain amount of power to run their cars. They must pay for this set amount day in and day out, regardless of the amount of current used. He further stated that a reliable storage battery would permit contracting for a smaller amount of current, and asked Mr. Hewett if the art of battery manufacture had reached such a point as to warrant such a change. Mr. Hewett answered yes, with the proviso that large cells of ample capacity be selected and proper care be taken of the entire plant.

The President announced the enforced absence of Mr. Maurice Hoopes, Electrical Engineer Lynn & Boston R. R. Co., Lynn, Mass., and directed the secretary to read his paper on "Power Distribution and Use of Multiphase Current Transmission for Ordinary Street Railways." We reprint this paper in full elsewhere in this issue.

At the opening of the third day's session the amendment of the by-law in which the time of meeting is defined as the third Tuesday in October was brought up. After much discussion it was finally amended that the Executive Committee may select any date between Sept. 15 and Dec. 31, depending upon the geographical location of the convention city. A letter from the Omaha City railway, asking discussion on the mail carrying question, was read. Mr. Dimmock, of Council Bluffs, said he did not expect much to be done at the present meeting, but the government seemed to be reducing rates and some method should be adopted to better the conditions.

The President remarked that on one St. Louis road, when a reduction was attempted, the mail car was quietly withdrawn from service. In another case a rate of 3½ cts. per mile was being paid, besides paying a portion of the salary of the postal clerk, who handles also the baggage, passengers, etc. The statements seemed to show that railways were generally able to secure a reasonable compensation if they insisted upon it.

The President then introduced Mr. Geo. H. Davis, Superintendent Canal & Claiborne R. R. Co., New Orleans, La., who read a paper entitled "Discipline of Employees." Mr. Davis said that all officers should have a definite rank. All orders should be worded clearly and concisely, and should be printed and sent with proper directions to those for whom it was intended. Both good and bad service should be noticed, the former by a complimentary personal letter. Before any man is discharged he should be given a chance to defend himself. On days when the travel is very heavy and overtime is required, the men should receive a portion of the increased earnings. In selecting men, some form of civil service examination should be adopted, the questions for which should be prepared by the man under whom the applicant will work. The applicant's previous history, his knowledge and skill, physical condition and quality of work should all be considered. A fixed line of promotion should exist, and as far as possible any position should be filled by men already employed.

At the meeting a year ago, a committee was appointed to prepare a standard code of rules for the use of motormen. This committee reported that through a misunderstanding it had not prepared such a code, and it was continued, with instructions to report next year.

Col. N. H. Heft then read a very interesting paper giving an account of the experience of the New York, New Haven & Hartford R. R. with electric traction. We will print this, nearly in full, in our next issue. Col. Heft stated, in reply to questions, that their third-rail construction cost about $3,000 per mile, which they had found to be about half the cost of overhead construction.

Mr. W. J. Hield, General Manager Twin City Rapid Transit Co., Minneapolis, Minn., was introduced by the President, and read a paper entitled "Best Method of Settling Damage Cases and Prevention of Accidents by the Use of Fenders or Otherwise." Mr. Hield said a great deal of the trouble with damage claims was due to the class of lawyers who prosecute trifling damage claims on commission. The claims department should have a competent man at its head, and careful and ample records of all accidents should be obtained and filed as soon as possible after they occur. The injured party or parties should be examined by the company's surgeon, and offers of attention and assistance extended. To antagonize any one who might bring in a claim is certainly poor policy. Upon the settlement of any claim a full release should be taken before witnesses. The claim agent should also be a firm believer in preventing accidents by precautions, and the claim and operating departments should work together. It is impossible to avoid all accidents, but careful men, good rules, regulated speeds, good car equipment, fenders and safety gates will do much to cut accident expenses down.

A proposition was brought forward to have the papers to be read at the annual convention printed and distributed to the members in advance of the meeting, but it was voted down. The nominating committee reported the following list of officers, who were duly elected:

President, Albion E. Lang, Toledo; Vice-President, W. Caryl Ely, Niagara Falls; Second Vice-President, John A. Rigg, Reading, Pa.; Third Vice-President, Edward G. Connette, Nashville, Tenn.; Secretary and Treasurer, T. C. Penington, Chicago; Executive Committee, Robert McCulloch, St. Louis; C. D. Wyman, New Orleans; H. C. Moore, Trenton, N. J.; John Roach, Chicago, and Robert S. Goff, Fall River, Mass.

Boston was chosen as the place for holding the 1898 convention.

While the business session was in progress the visiting ladies, under the guidance of the Ladies' Reception Committee, enjoyed a trip to Youngstown and Fort Niagara, over the Great Gorge Route & Frontier R. R. At the Eldorado Hotel, Youngstown, a luncheon was served. The evening was devoted to the annual banquet, held in the International Hotel and about 300 delegates and supply men sat at the tables. The 42d Separate Company band furnished music, while under the excellent guidance of the toastmaster, Mr. W. Caryl Ely, the following toasts were given: "The City of Niagara Falls," the Hon. Arthur C. Hastings; "The Association," Smith P. Galt; "Wit and Humor of the Bar," Henry W. Box; "The Evolution of Niagara," the Hon. Thomas V. Welch; "The Railroad Commissioners," the Hon. Ashley W. Cole; "The Technical Press," Henry M. Windsor.

The morning of the last day was devoted to the installation of officers and final adjournment. A summation of the four convention days cannot help but be pleasing to all interested in the welfare of the association. The attendance was larger than ever before, and in both quantity and character the exhibits far surpassed those at St. Louis. The display of large and heavy machinery was remarkable. In our Construction News department will be found a detailed list of the exhibits.